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BRITISH SURGICAL PRACTICE

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BY ARNOLD K. HENRY, M.B., M.CH.(HON.) CAIRO, F.R.C.S.I.
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1. GRADING OF SURGICAL VARIETIES OF SPLEEN DISEASE

308.] Setting apart conditions such as splenic rupture, abscess, cyst, or tumour, the nature of response to a splenectomy allows a grading of surgical varieties of spleen disease as follows.

(1) Diseases in which splenectomy
- (a) affords a majority of good, durable results
  - (i) familial acholuric jaundice (causing disability)
  - (ii) chronic essential thrombocytopenic purpura
- (b) affords the only known (if imperfect) operative treatment
  - (i) acute essential thrombocytopenic purpura
  - (ii) acquired haemolytic jaundice.

(2) Diseases in which splenectomy affords uncertain, often transient, improvement and calls for supplemental operations
  Banti's syndrome (including Egyptian splenomegaly, cases of portal block or of hepatic cirrhosis—each with increased portal pressure).

(3) Diseases in which splenectomy is still on trial, or is appropriate in rare and special cases when other measures fail.

2. LACERATIONS OF THE SPLEEN OR SPLENIC PEDICLE

Lacerations can be considered as subcutaneous ruptures due to injury, spontaneous ruptures, and penetrating wounds.

(1) Traumatic rupture

Predisposing causes

Local and severe impact, with or without rib fracture, is needed to rupture a normal spleen, but large spleens (especially in malaria) tear so easily that in some malarial regions a mere tap from fingers on the belly is a major offence. Infarcted spleens are rarer predisposing causes.

(a) *Haemorrhage*

Complete detachment

Haemorrhage follows laceration, sometimes intractably, as happens with complete detachment of the spleen. As a rule, however, bleeding is slow enough to leave time for intervention.

Rupture with delayed bleeding

Fragile vessels

Again, as in the liver, a type of splenic injury occurs in which there is an interval of hours, days or (very rarely) weeks between the causal impact and the start of bleeding. Delaying factors include clotting when blood-pressure falls during initial shock; omental sealing; bleeding that is mainly intracapsular and is slow to gather and break out. Hamilton Bailey (1930) has stressed the special risk from flimsy pedicles in these delayed cases—a risk also shared by major vessels of a limb which have been left steeping in closed effusions of partly clotted blood.

(b) *Symptoms*

Local or general tenderness

Rigidity and vomiting

Classical signs and symptoms of bleeding are often absent. Initial shock has sometimes passed before the patient is examined. Pulse rates, with a quart of blood in the abdomen, even in children, may be unexpectedly low (90–100) General abdominal tenderness accompanies or follows that over the spleen; it is late if caused by overflow from a full lesser sac, or by leakage round the barrier of stomach, colon and omentum, and early if blood flows directly into the greater sac, or if vomiting disturbs the barrier (O'Connell, 1946). Rigidity, too, may be general or left-sided for the same reasons. Vomiting is often absent.

(c) *Special clinical signs*

Kehr's shoulder sign

O'Connell's adaptation

The presence of left-shoulder pain appearing early after injury suggests a diagnosis of splenic haemorrhage (Kehr), but the pain is often absent (in one series of 28 cases it was found only 3 times). O'Connell (1946), however, noticed that in patients who were bleeding from ectopic pregnancy shoulder pain appeared on either side or both after he had raised the foot of the bed. He was thus able to educe the pain in splenic laceration when it was not at first complained of by the patient. Free blood could then reach the diaphragm and stimulate cervical segments through the phrenic nerve.

Saegesser's sign

A second phrenic sign whose helpfulness needs confirmation is Saegesser's sign: pressure, in the presence of a bleeding spleen, made between the left sternomastoid muscle and the scalenus anterior muscle at the lower third of the neck is said to cause pain, violent by comparison with that produced

on the right side. Fixed dullness in the left flank sometimes, though rarely, occurs in combination with shifting dullness in the right flank (Ballance's sign) When it does, the fixed left-sided dullness is due to local clotting induced by lacerated splenic pulp.

Ballance's sign

(*d*) *Radiological signs*

Patients are often examined radiologically for rib fracture, and Webb describes four signs suggesting splenic rupture: (1) increased density in the left upper quadrant; (2) elevation of the left dome of the diaphragm; (3) displacement of the stomach to the right, and (4) fluid separating segments of the gut. An injured spleen, like injured brains or livers, can cause death after deceptive "lucid" intervals; cases which are suspect should therefore be warded for observation.

(*e*) *Mortality*

The mortality from "closed" splenic injury stands today between 20 and 30 per cent. Much of this high rate is due to lesions elsewhere, but some of it certainly occurs because the surgeon, unless he works abroad, is likely to see few cases. (The London Hospital had only 32 in 34 years) He therefore may expect, or wait for, graver signs before he intervenes.

(2) Spontaneous rupture

Berger collected 123 cases of spontaneous rupture; the absence of any history of injury in such a number is remarkable. Of the patients, 99 were malarial, while of 28 cases collected by Wohl (1925) 14 had typhoid fever. Other associated conditions are infarction, cysts, abscess, *haemophilia*, *Hodgkin's* disease, Banti's syndrome, leukaemia, acute infections, typhus, relapsing fever, the granulomas and kala-azar Susman (1925) could find only 7 cases in which atraumatic rupture had occurred in an apparently healthy spleen, but of these patients only 2 were well at the time, 4 having biliary or intestinal disorders, and 1 having pulmonary tuberculosis.

It is difficult to explain these ruptures if the spleens are really normal. Some have occurred after a meal, when the spleen is engorged; others after strain—reaching to put out a light, defaecation, childbirth, and coitus.

(3) Penetrating wounds of the spleen

The spleen is so friable and so engorged with blood that stab wounds rarely pierce it without causing serious haemorrhage, while shell or bullet wounds will often totally disrupt it. Clinical punctures of the spleen have often bled, and it is well to have the subjects of these tests prepared for laparotomy lest such an accident should occur.

(4) Treatment of splenic lacerations

Mortality

Berger reported 220 unoperated cases with a mortality of 92·3 per cent. Ruptured spleens, in general, are treated by splenectomy (*see* p. 18), which finally removes a menace.

The spleen is friable, especially when injured; for that reason it holds sutures poorly. Tamponade, however, should not be forgotten; in the past it has given notable results: Quénu (1926) quotes 26 cases saved out of 31,

which is under half the present-day mortality from removing ruptured spleens. It leaves in place, however, a damaged organ, but it can save life *in cases in which the surgeon is faced with multiple injury, when blood* pours, time presses, and gut leaks. A single Mikulicz pack (or, if it fails, a double one) will compress the bleeding viscus. The batiste square whose centre is invaginated as a sac, should have an area sufficient for every portion of its edge to emerge liberally. The pressure from inserted swabs (*or, better, from unrolled lengths of Vaselined* bandage marked at their protruding ends by knots) can be cautiously reduced within a few hours, leaving in place, of course, the sac. After 4 or 5 days this, too, comes away on testing gently round its edge. Any part resisting must on no account be forced. *The Mikulicz tampon*

3. ABSCESS OF THE SPLEEN

This condition is most often secondary to disease elsewhere. Many cases of left-sided subphrenic abscess originate as abscess of the spleen, and, as a rule, result from contiguous, or from metastatic infection; the latter is more frequent, and begins with clotting or from emboli (Elting, 1915). Contiguous infection spreads from the lung, sometimes after injury; from the colon, rarely from the stomach. The appendix or Fallopian tube are distant sources of infection, and splenic abscess follows typhoid fever, dysentery, relapsing fever and influenza. The abscess following typhoid fever is said to have the best prognosis. Chronic tuberculous abscess may occur. *Secondary abscess*

The clinical and radiological signs are those of left subphrenic abscess (*see* p. 104). *Aspiration reveals pus, and operation shows its site.*

Primary splenic abscess of unknown origin occurs in Northern Rhodesia and in Mashonaland in Southern Rhodesia In company with foul-smelling gas the abscess may contain many pints of chocolate-brown pus; a swelling therefore which corresponds in shape and position to an enlarged spleen *and which is tympanitic on percussion, is pathognomonic of this condition* (Wallace, 1922, Gelfand, 1947). The swelling is noticed by the patient, following pyrexia Skiagrams show gas beneath the phrenic cupola over a fluid level, together with displacement of the heart. Venous thromboses in limbs, brain, or abdomen are common complications. Emetine is useless; treatment is by *drainage. The abscess, if neglected, ruptures into the* peritoneum. *Primary splenic abscess in S. Africa*

4. SPLENIC CYSTS AND TUMOURS

(1) Cysts

Nearly 50 per cent of splenic cysts are found *post mortem.* They can be classified as (1) parasitic (most of which are echinococcal, occurring in 2 per cent of infestations); (2) dermoid cysts; and (3) "simple" cysts. *Varieties of cyst*

The simple cysts may be large and solitary (*often with haemorrhagic* contents, sometimes after trauma); small and multiple; or of mixed variety.

Only large cysts, or those that calcify, will be recognized apart from laparotomy. If non-adherent, cysts give trouble from their size, or if they press upon the heart, the treatment is splenectomy. Adherent cysts may call for drainage or marsupialization.

(2) Tumours

Neoplasms are rare: sarcomas have been reported. Angiomas are less uncommon; they seldom are detectable by clinical examination, except when they rupture.

5. HAEMOLYTIC (ACHOLURIC) JAUNDICE

Signs in uncomplicated forms

This is linked with an increased destruction of red blood corpuscles, a gross excess of bilirubin in the blood, and enlargement of the spleen. The jaundice is of the non-obstructive kind: there is absence of itching and petechiae; the stools are not clay-coloured; the urine is free from bile pigment. The van den Bergh reaction for bilirubin is indirect.

The part played by bilirubin

Excess of circulating bilirubin gives rise to an excess of urobilin in faeces and urine; intestinal organisms change bilirubin into stercobilin, and this, absorbed back into the blood and subsequently oxidized, may then appear in a sufficient quantity to make the urine brown with urobilin. Chronic pigmented ulcers of the leg are not uncommon.

The surplus bilirubin thickens the bile and leads, in more than half the cases, to formation of gall-stones made of pigment. These can block the bile duct and give rise to signs that blur the non-obstructive acholuric picture. The bile itself may be so viscid as to cause colic.

(a) *Spherocytes and fragility*

The influence of red-cell shape on fragility

Red cells in haemolytic jaundice have usually two associated characters: they are more fragile than normal because they are more spherical than normal. For that reason they are able to absorb less fluid from hypotonic solutions without the risk of bursting than if they were of normal biconcave shape, and so they burst at saline concentrations only very slightly less than that of normal saline. Thus, in haemolytic jaundice haemolysis may start at 0·75 per cent, and be complete around the titre at which an haemolysis of normal cells will only just begin, namely 0·45 per cent.

Anaemia with absence of fragility

An average anaemia in haemolytic jaundice shows 2,500,000 red cells per cubic millimetre. It is important, however, to realize that some red cells will always resist diluted saline better than others, and when these others have been haemolysed destruction of the more robust will then occur at much the same dilution (0·45 per cent) as would destroy a normal cell. It follows that in certain cases of acholuric jaundice already made anaemic by the loss of all their less resistant cells, residual corpuscles are normal when tested for fragility. Gänsslen, Zipperlen and Schüz (1925) in a study of 105 cases found 10 per cent with no fragility. If this anaemia is checked (as by splenectomy), new spherocytes—the countersigns of this disease—come into circulation; and so a typical fragility returns. The normal red cells of the goat are spherocytes and have about the same fragility in saline solution as cells of human acholurics.

(b) The spleen as filter

It seems possible that, quite apart from the activity of reticulo-endothelial (macrophage) cells which line the spaces of the splenic pulp, the spleen can function as a red-corpuscle filter, letting pass the flattish thinned-out discs of normal blood and barring passage to rounder types of red corpuscle. These spherocytes which feature in a case of haemolytic jaundice are stopped at slit-like stomas through which the venous sinuses take blood from a pulp space. That is perhaps part of the reason why splenectomy can often check anaemia in haemolytic jaundice, though it leaves the shape and therefore the fragility of spherocytes unaltered. The finding by microscopy of splenic pulp spaces distended and distorted by masses of packed red cells (Wintrobe, 1946) supports the view that the trapping of spherocytes by filtration precedes their destruction.

Reticulocytes

Reticulocytes are numerous, especially in acute cases. They are the sign of a precipitate replacement of corpuscles after haemolysis or bleeding. In spite of the similarity of name they are, of course, distinct from reticulo-endothelial cells.

(1) Familial and acquired haemolytic jaundice

Recent biological tests confirm the long-disputed view that these two main forms of haemolytic jaundice are separate conditions, though jaundice of familial type with delayed onset is frequently mistaken for the more dangerous acquired type.

(a) Basic difference between familial and acquired types

The cell defects in the familial type

If red corpuscles from a normal subject are introduced into the blood of patients with familial haemolytic jaundice, the "lives" of the normal blood cells average a normal 100-day duration. But blood cells from patients with familial haemolytic jaundice quickly perish when transferred to normal blood. The fault is therefore in the cells of those with familial haemolytic jaundice.

The haemolysin of acquired types

If corpuscles from a normal subject are introduced into the blood of patients with acquired haemolytic jaundice, they quickly disappear, while, on the other hand, "acquired" cells in normal blood persist, exactly like the normal. The fault lies therefore in the presence of abnormal haemolysin in the blood of a case of acquired haemolytic jaundice.

The Coombs test used to recognize acquired haemolytic jaundice

Knowing therefore that a haemolysin was present in the blood of patients with acquired haemolytic jaundice, investigators guessed that their residual, unhaemolysed, red cells might still retain adsorbed to them some trace of haemolysin, too impotent, however, to haemolyse, or even to agglutinate. Assuming then that this too-weak (or so-called "blocked") haemolysin resembled others of the class and was a globulin, they next prepared for its detection an antiglobulin serum by injecting rabbits with human globulin. This antiglobulin serum when mixed with red cells (previously washed free of all but adsorbed globulin) at once agglutinated cells from the acquired type of case, but never those from the familial.

(b) Familial acholuric jaundice

This condition appears as a Mendelian dominant passed on by either sex to certain members of a family, the whole of which, however, may be marked by red-cell abnormalities. The lemon-yellow tint of jaundice often

starts in infancy, or may appear in youth, or even during middle life. Certain affected persons, apart from sallowness, live normally and never need specific therapy. In others, casual infections (especially in children) provoke the so-called crises: the patient has malaise, perhaps with fever, nausea and vomiting; the spleen swells and its site is tender; the liver may enlarge; sudden anaemia due to much haemolysis will cause dyspnoea; urobilin darkens the urine when it stands exposed to air. These crises of familial jaundice are more often repeatedly troublesome than fatal, but their possible acute appearance must be kept in mind.

The crises

(c) *Acquired acholuric jaundice*

Late onset of signs and symptoms

In this rare type of jaundice the onset of signs and symptoms often comes later in life. Crises are frequent and sharper; more deadly in themselves they multiply the risks of a coincident splenectomy. Apart from mistimed effort, much of the total operative death rate (3–5 per cent) for all forms of haemolytic jaundice seems to accompany a swift sequence of crises in the acquired form, which none the less demand removal of the spleen.

Acquired forms, the common feature of which is the presence of a haemolysin, admit varieties that can be grouped as non-familial jaundice which is either (i) of unknown origin, or (ii) symptomatic. The first group includes the so-called Lederer's anaemia, curable by blood transfusion in about a third of the cases. The second group includes forms associated with some ailment such as Hodgkin's disease, tuberculosis, syphilis, leukaemia, cancer of the tail of the pancreas and ovarian cyst. Spherocytosis coupled with fragility occurs in both these groups but frequently is absent. After splenectomy the shape of red cells, and also their resistance, may revert to normal—unlike what happens in familial types (though Lendvai (1949) reports reversion after splenectomy in three cases from a family with oval red cells).

Shape and resistance of red cells after splenectomy

Blood transfusion in the presence of haemolysins

Transfusion of patients with acquired acholuric jaundice who harbour haemolysins is sometimes dangerous: blood seemingly compatible in glass-slide tests may yet cause grave reaction. Donors' blood of the same type should be matched, therefore, by using test-tube methods which reveal the presence of such haemolysins as might act without the prelude of agglutination.

(2) Indications for splenectomy in haemolytic jaundice

Overt disability must be present; latent cases of familial type need no treatment. Disability may be due to crises arising from anaemia; to impairment of bodily or mental development; or to ulcer of the leg occurring at the ankle over a malleolus. Such ulcers, when refractory, are cured by splenectomy.

Splenectomy should be performed if possible during a remission, sometimes obtainable by blood transfusion. If transfusion fails in an acute case, the spleen should be removed at once. In the acquired type splenectomy has saved life even when the patient was moribund (Dameshek, 1940).

Gall-stones complicating haemolytic jaundice

When gall-stones complicating haemolytic jaundice require operation, and when it is not advisable to remove both the spleen and the gall-bladder

at the same session, ". . . operation on the spleen should take precedence over that on the gall-bladder." (Pemberton and Kiernan, 1945.)

(3) Results of treatment

The total operative mortality for all cases of haemolytic jaundice is about 5 per cent. Within recent years the rate has fallen to about 3 per cent. Late results of splenectomy at the Mayo Clinic are as follows: of 162 patients who were traced 89 per cent were alive after 5 years, 81 per cent after 10 years, and 67 per cent after 20 years.

6. ESSENTIAL THROMBOCYTOPENIA

Incidence and signs

Essential thrombocytopenia (idiopathic purpura haemorrhagica) which may begin at birth and, rarely, after the age of forty, is marked by multiple haemorrhages into skin, forming petechiae chiefly on the lower extremities, and also by haemorrhage from any mucous membrane (especially the uterine mucous membrane in girls). Bleeding is associated with a reduced platelet count, a prolonged bleeding time, normal coagulation time and a lack of proper clot retraction. The spleen never extends more than about a finger's breadth below the ribs, and then only in one third of the cases.

Decrease in number of platelets

Thrombocytopenia is thought to be produced by a dysfunction of the spleen, which in some way inhibits the megakaryocytes, each of which is formed from fusion of several of the macrophage cells that characterize the reticulo-endothelial system. These megakaryocytes are parent cells of thrombocytes, or platelets, and though the numbers of these parent cells are normal in a specimen obtained by sternal puncture, they seem unable to produce their normal quantity of platelet offspring; the condition is therefore a "maturation defect". It seems certain, however, that thrombocytopenia is not the sole factor concerned in producing haemorrhagic purpura: the number of platelets may not rise to normal after a curative splenectomy, or, if it does, may fall later; yet haemorrhage is absent. Their mere reduction, too, is not infallibly accompanied by haemorrhage (though bleeding often starts when they fall below 40,000 per cubic millimetre). Furthermore, in some purpuric conditions, such as scurvy, the platelet count is not reduced.

Capillary frailty

Capillaries are frail in thrombocytopenic purpura. This can be shown by raising the pressure in a pneumatic armlet midway between systolic and diastolic levels for 5 minutes. When the armlet is removed and the test is positive, purpuric spots one millimetre to one centimetre in diameter appear on the skin. During remissions the platelet count may be normal but the pressure test still shows capillary frailty.

The major sign

Anaemia, proportional to blood loss and without abnormal cells, is the outstanding feature. Apart from anaemic symptoms, the patient feels fairly well.

(1) Diagnosis

Bleeding time

This depends first on excluding all forms of symptomatic purpura. Bleeding time will be found prolonged beyond the normal 3–5 minutes, because of the deficiency of platelets. Coagulation time is normal and this serves (with the platelet count) to distinguish the condition from haemophilia,

Coagulation time

Clot retraction

for which it might be mistaken, even during a remission period, because of ecchymoses produced by light tapping over bony prominences. Clot retraction is defective, and the clot may be spongy and friable for many hours, coming apart if picked up by a needle. When spicules of fibrin form in clot, platelets adhere to them and show as knots upon their intersections; the spicules then proceed to bend, twist and shorten, causing clot retraction (syneresis) which helps to close the lumen of a bleeding vessel. Only two tissues can make a non-retracting clot retract, namely bone marrow and spleen; the marrow holds the parent cells of platelets; the spleen is where the platelets congregate. Since bleeding often recurs from one structure (uterus, gut, nose or gums), it is well to exclude in the mouth or nose the rare presence of telangiectases which sometimes are inherited.

The absence of certain signs such as the joint pains and toxaemia of Henoch's purpura or the faucial ulceration of agranulocytic angina is also helpful.

The need for sternal puncture

Aplastic anaemia

Aleukaemic leukaemia

The marrow picture and splenectomy

Two conditions have been a special cause of diagnostic difficulty: aplastic anaemia in which the production of all blood cells is diminished, and aleukaemic leukaemia where white cells or their precursors accumulate in organs and fill the marrow but are not increased in the blood. Sternal puncture establishes the picture peculiar to each condition and distinguishes them both from idiopathic thrombocytopenic purpura. In this the number of immature megakaryocytes in marrow is as a rule increased—a fact which favours splenectomy. Decrease, however, of these mother cells of platelets suggests a shift towards aplasia, which contra-indicates the operation and calls instead for blood transfusions. These can sometimes re-establish a sufficient crop of megakaryocytes to make splenectomy successful.

Eosinophils

Sternal puncture may have further bearing on treatment and prognosis. Schwartz (1945) noticed that spontaneous recovery occurred in cases when the ratio of eosinophils in marrow to the more immediate (metamyelocyte) precursors of polymorphonuclear cells was greater than 50 per thousand. Splenectomy, he thought, should be confined to cases where no such eosinophilia was found.

(2) Forms of the disease and indications for splenectomy

The chronic form

Sex incidence

Chance of continued recovery after treatment

Essential thrombocytopenic purpura is the only condition, except rupture of the spleen, in which splenomegaly is not part of the indication for splenectomy. A chronic form of the disease in which improvement is the rule accounts for relatively mild conditions found in over 80 per cent of cases. More than two-thirds, however, show relapse after a first episode, in weeks or months, but as a rule within 4 years; they have a sex proportion of two females to one male. Wintrobe (1946) finds that "the chances for continued recovery following conservative or medical treatment are less than 1 out of 3. Following successful splenectomy, on the other hand, the chance for continued recovery is almost 3 out of 4 in cases in which there has only been one episode of bleeding and somewhat better than 1 out of 2 in cases in which several episodes had occurred before operation". Splenectomy can therefore be considered with tempered optimism. The frail capillaries recover normal powers of resistance in about 10 minutes

after the pedicle is tied, and active bleeding often stops immediately. The operation should be performed during a remission.

The acute form The acute form (under 20 per cent of cases) is responsible for most of the total 5 per cent mortality from operation in idiopathic purpura. Splenectomy gives far less sure results than in the chronic form though, when transfusions fail, nothing but splenectomy is capable of saving life. It may also avert an intrameningeal haemorrhage.

Bleeding the major indication In either form of this disease, therefore, bleeding endangering the patient (especially the female) and not controllable by other means, gives clear indication for splenectomy. In chronic or recurrent cases with milder haemorrhage, economic or social conditions may require it. The chance, too, that a fatal haemorrhage may follow later, perhaps into the brain or cord, must be remembered. *The place of blood transfusion* Blood transfusion is the first step in treating these cases. Sometimes it will cure. More often it prepares the patient for safe splenectomy.

Ligation of the splenic artery Ligation of the splenic artery has been used with some success in patients too ill for the major operation.

(3) Late results of splenectomy in essential thrombocytopenic purpura

Of 82 splenectomized patients who were traced at the Mayo Clinic, 71 lived beyond the 5-year period (86·6 per cent). The 10-year survival rate was 79 per cent. Only 2 patients were traced who had been operated on more than 20 years back; both were well (Pemberton and Kiernan, 1945).

7. SPLENIC ANAEMIA (BANTI'S SYNDROME)

(1) Aetiology

Whipple (1945) believes that splenic anaemia is due to mechanical obstruction to blood flow in the portal bed. This, he finds, may be produced by:

(a) intrahepatic block due to hepatic cirrhosis; or

(b) extrahepatic block due to

(i) fibrous-tissue replacement of the portal vein or its main branches or *tributaries, caused as a rule either by organization of a* thrombus following trauma, direct inflammation or pressure of inflammatory or neoplastic tissue, or by extension, into the main portal vein or its left branch, of the obliterative fibrotic process that begins at birth in ductus venosus and umbilical vein and continues during childhood, or

(ii) transformation of the portal vein or its main tributaries into a cavernomatous mass, possibly by combinations of the following: organized thrombus and canalization; telangiectatic granulation tissue; neoplastic angiomatous formation spreading beyond the limits of the portal vein.

It will be seen that Whipple brings the splenic anaemias of childhood into line with those of adult life. The latter, however, show a leucopenia, while the children often, though not always, show leucocytosis.

The relation of Egyptian splenomegaly to Banti's syndrome Rousselot and Thompson (1939) by repeated injection of fine silicate particles into the portal system of dogs have produced a condition which they believe is almost identical with the severe portal cirrhosis, splenomegaly, and compensatory collateral circulation seen with infestation by *Schistosoma*

mansoni in Egypt, where Whipple thinks that fragmented ova of the parasit produce Egyptian splenomegaly. The animals, if allowed to live, develop massive ascites and big oesophageal varices—a finding rare in patients with schistosomal splenomegaly in Egypt, who seldom vomit blood, though their condition is otherwise extremely difficult to separate from splenic anaemia. Possibly the difference is due to seeping portal haemorrhage from the large intestine, which is, or has long been, present in patients with *S. mansoni* infestation: the loss perhaps gives just enough relief of portal pressure to inhibit the formation of oesophageal varices.

The syndrome of portal block

The syndrome of portal block may now be provisionally summarized as follows: splenomegaly; a tendency to repeated gastro-intestinal haemorrhage, usually from ruptured oesophageal varices; variable secondary anaemia, becoming microcytic and hypochromic as bleeding recurs; leucopenia in which white cells keep their normal ratios. The liver may be cirrhotic or normal, depending on whether the block is intrahepatic or extrahepatic. The onset is often insidious but is sometimes marked by haematemesis or tarry stools.

(2) Diagnosis and location of the site of block

Banti's syndrome can be distinguished from other splenomegalies by the signs and symptoms already given, especially by the blood picture. The syndrome has, however, been confused with almost every kind of splenomegaly that is associated with infection, parasites, haemolysis, or the abnormal lipoid storage of Gaucher's disease. Sternal puncture serves to exclude aleukaemic leukaemia, and it should be remembered that "silent" slowly bleeding duodenal ulcer may produce a hypochromic microcytic anaemia accompanied by slight splenic enlargement.

(a) *Position of portal block*

Tests for liver function to determine the site of block

The relative position of the portal block, whether intrahepatic or extrahepatic, can be determined by four tests for liver function: (1) high retention of bromsulphalein in the blood 30 minutes after intravenous injection; (2) a positive hippuric acid test; (3) reversal of the albumin-globulin ratio; and (4) a positive cephalin flocculation test. With these results the presence of cirrhosis and of intrahepatic portal block is fairly certain (Whipple, 1945); if all four tests are in reverse the block is extrahepatic.

If liver function is normal and there is a history of pancreatitis or of severe epigastric injury in presence of a Banti syndrome, thrombosis of the splenic vein should be suspected; while if the patient is a child who has a history of haematemesis, and tests for liver function are normal, a portal occlusion resulting from the developmental process of obliteration spreading beyond the umbilical vein and ductus venosus is very likely present.

(b) *Oesophageal varices*

These can be detected by the endoscope (which itself may provoke bleeding), and also by radiography (Fig. 1). If barium is used, the filling defects caused by the varices show up after the bulk of the bolus passes on into the stomach. Lipiodol is perhaps a better medium; it should be swallowed slowly while the patient is supine (Brailsford, 1946).

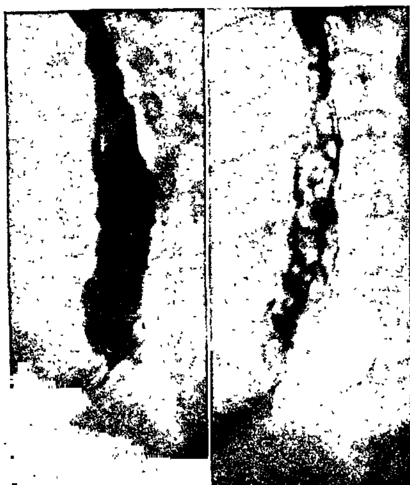


FIG. 1.—Oesophageal varices (*Medical Annual*)

(3) Treatment

Two things indicate the need for surgical treatment: the size of the spleen and the incidence of gastro-intestinal bleeding These in turn depend on the degree of portal hypertension and on development of collateral circulation leading to varicosities at the junction of oesophagus and stomach, which bleed from surface ulceration. If the block is in the splenic vein (a somewhat rare site) splenectomy by removing a drainage area which contributes about 40 per cent of portal blood may sometimes arrest the Banti syndrome, the outcome as to haemorrhage depends on where a gastric tributary ends. Blakemore and Lord (1945) point out that a majority of anatomists describe the left gastric (coronary) vein as entering the splenic vein and not the portal vein. It may do either—a point important in a Banti syndrome accompanied by haematemesis (Fig. 2) Because of this alternative ending, it does not follow that mere removal of the spleen will stop recurring haemorrhage from cardio-oesophageal varices, for, if the block in the splenic vein is on the portal side of where the coronary vein enters it, pressure can travel back unchecked along that tributary towards the bleeding area. This common debouchment of the coronary vein into the splenic vein

Splenic vein block

Varying debouchment of left gastric vein

Portal vein block

is often inaccessibly placed for direct examination during life. If the block is in the portal trunk, or even in the liver, removal of the spleen at least reduces portal tension and relieves the patient, sometimes for years. He none the less remains exposed to haemorrhage from back-pressure reaching the varices through gastric veins.

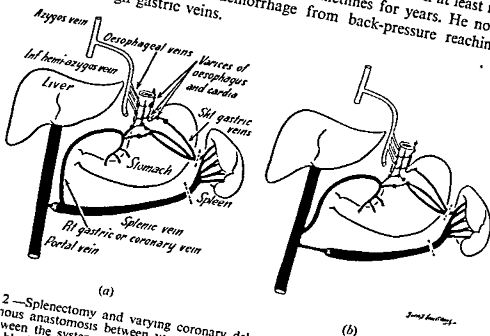


FIG 2.—Splenectomy and varying coronary debouchment. The figures both show, the venous anastomosis between veins of stomach, oesophagus, and spleen; and the link between the systemic azygos veins (unshaded) and portal tributaries (shaded). When the block is in the splenic vein at X splenectomy (which removes 40 per cent of portal blood) will partially relieve congestion in the varices if the coronary vein ends as in (a). If it ends as in (b), relief is complete

Recurring haemorrhage is thus a leading problem Ligation of veins that feed oesophageal varices is disappointing: the portal pressure is increased in gastric veins by that ligation, and, after an interval, there is either an opening up of more venous connexions with the varices, or the formation of new varices on the stomach side of the cardiac opening. In each case haematemesis recurs.

(a) *Anastomosis of portal vein with systemic vein*

The failure after ligation of veins, together with that of high proportions of Talma-Morison procedures (omentum fixed to abraded liver or to split rectus muscle), caused surgeons to review the possibility of shunting blood from portal to systemic veins, reverting to a first attempt by Gunn of Dublin (1911) who joined the right ovarian vein to the portal vein. In 1913 Bogorts achieved the first success along these lines, resorbing an ascites by a union of the superior mesenteric vein with the inferior vena cava.

The recent means of vein anastomosis is essentially an independent rediscovery by Blakemore and Lord (1945) of Quierolo's method (1893). This procured an Eck's fistula or portocaval union in dogs, by dividing the portal vein caudally and passing it down through a glass tube as through a sleeve. The wall of the emerging vein was then turned back like a reversed cuff over the end of the glass sleeve. The glass thus coated with everted vein was passed through the lips of an opening in the vena cava, which were then tied round it, taking care the ligature did not enter the lumen; intima was

therefore left in contact with nothing but intima. This swift and simple means is now perfected by using tubes of non-corroding metal.

Venous pressure and the site of extrahepatic block.—A choice of portal segments suitable for anastomosis with a systemic vein (whether inferior vena cava or left renal vein) can be far better made by pressure tests than by venography. Opaque material within the vein will flow in general along the path of least resistance, away from the block towards the cardio-oesophageal varices, and thus will be uninformative. On the other hand a manometric test will show whether pressure in the available portal segment is raised above the normal height of ± 65 millimetres of water; and since it may stand at seven times that height in portal block the likely value of joining a portal segment with systemic veins can be assessed It is of course futile to use low-pressure segments of portal veins for anastomosis. *Normal portal pressure and its increase*

(*b*) *Arrest of active haemorrhage in Banti's syndrome*

Provided that the bleeding comes from oesophageal varices and not from varices within the stomach, a Miller-Abbott tube with the bag shifted a span up can stop it (Tanner, 1949) (Fig. 3). One of the channels in the tube is connected with the bag, which can then be dilated or relaxed while feeding *Use of the Miller-Abbott tube*

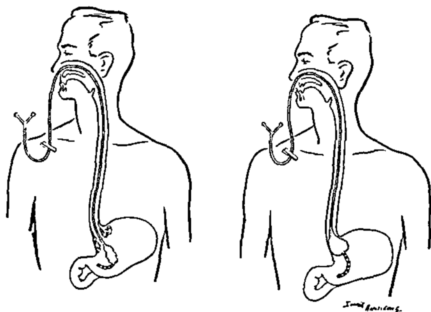


FIG. 3.—Showing position of Miller-Abbott tube with bag in arresting haemorrhage from oesophageal varices.

or aspiration proceeds. The bag is swallowed by the patient, dilated in the stomach, withdrawn to the cardia, deflated, withdrawn 4–5 centimetres farther and re-inflated in the lowest part of the oesophagus; it may be left inflated for 3 or 4 days (this is a modification of the method of Rowntree and his colleagues, 1947). Pressure from the bag falls less on varicose veins than on their anastomoses with the coronary vein, and it is worth noting that in one case, where this must have been the chief remaining path fo portal blood, the bag controlled the bleeding but produced

(4) Results of splenectomy for Banti's syndrome

Certain follow-up statistics from the Mayo Clinic suggest the need for sor procedure that will supplement or replace splenectomy in treating th condition. Of 272 patients who underwent splenectomy for Banti's syndrom 29 died in hospital (10·7 per cent). Of these 29, 6 died of haemorrhage anc 14 of thrombosis. Of the 173 who had bleeding before the operation, 93 (53·7 per cent) had recurrent bleeding after the operation. Late results were as follows: of 208 of these splenectomized patients who were traced, only 54·8 per cent were alive after 5 years; 42 per cent after 10 years; 23 per cent after 20 years.

(5) Results of anastomoses between portal and systemic veins

Over 30 cases have been reported (Blakemore and Lord, 1945; Linton, Hardy and Orwiler, 1948). Operative mortality is about 10 per cent, which is not high considering the newness of the technique and the advanced conditions for which anastomoses have been practised. Linton believes their main effect is to reduce the gravity of haemorrhage. Injection of varices through an endoscope, as used by Moersch (1947) and Tanner (1949), will doubtless find a new indication after a portocaval shunt has been established.

8. THE RARER INDICATIONS FOR SPLENECTOMY

Bulk

Haemorrhage

Removal of a focus

"Resistant" spleens in syphilis

The "wandering" spleen

Mere size of the spleen can gravely incommode the patient by causing vomiting, dyspnoea, or cyanosis. This bulk in Gaucher's disease, and in malaria when therapy has failed, may justify removal of the spleen. In haemorrhagic forms of Gaucher's lesion it stops the bleeding, though not the course of the disease. Malarial spleens are notorious for brittleness and for adhesions. Use of the high-frequency current in dealing with the latter (*see* p. 18) will simplify the operation. Malarial relapse, resisting drugs, has sometimes been abolished by splenectomy, and fear of haemorrhage from minor local injury affords in such a case a further indication. Abroad, where problems of late untreated syphilis confront the surgeon, there will occur, as in malaria, the old, refractory condition. It is therefore worth noting that, in 1917, Mayo reported 5 cases in which prolonged treatment had neither reduced the splenomegaly nor checked anaemia, but in which splenectomy gave quick and excellent results. A "wandering" spleen, enlarged or not, that drags on the stomach, twists its pedicle, loops round the gut, or herniates, will also need removal.

(1) Uncommon leucopenic conditions

(*a*) *Felty's syndrome (splenomegaly, leucopenia, polyarthritis)*

This condition has been labelled unresponsive to splenectomy. A case, however, resisting other forms of treatment for years, has recently returned to farm work after operation, with restitution of granulocytes and absence of disability (Zimmer, 1945).

(*b*) *Primary splenic neutropenia*

Among the forms of agranulocytosis or granulocytopenia, Wiseman and Doan (1942) describe a new variety, with splenomegaly. It is characterized

by fever, pain over the spleen, and normal or somewhat hyperplastic bone marrow obtained by sternal puncture. Splenectomy relieves all symptoms. The spleens show great increase in their reticulo-endothelial cells (the macrophages), with excessive phagocytosis of granulocytes.

(*c*) "*Panhaematopenia*"

Atypical cases of otherwise intractable severe anaemia have recently been cured by splenectomy. Post-operative studies of the spleens with supravital stains (which by-pass nuclei and stain live cytoplasmic structures) show an excessive phagocytosis, not only of granulocytes, but also of platelets and red corpuscles, which are ingested and destroyed by splenic macrophages (Doan and Wright, 1946). This condition, and neutropenia with splenomegaly, are fresh examples of perverted splenic function.

(2) Conclusions

Research is likely to extend the indications for splenectomy, employed alone or in association with x-rays, radio-active isotopes, or nitrogen mustard compounds. It should, perhaps, be noted that x-ray therapy, which subsequently shelved splenectomy as treatment for a myelogenous leukaemia, was able first to make the operation safe for that disease.

9. PRE-OPERATIVE AND POST-OPERATIVE TREATMENT IN SPLENIC SURGERY

Pre-operative and post-operative treatment comprises (1) correction of anaemia by drugs, and by transfusions made with the precautions already noted (*see* p. 8); (2) treatment of associated conditions, infective or parasitic; (3) respiratory training, especially of lung bases, by a physiotherapist, before and after operation; and (4) early mobilization of patients after operation to avoid thrombosis.

Dicoumarol and heparin in checking thrombosis and embolism

These drugs, after splenectomy, when haemorrhage is likely, should be used only if the patient shows evidence at operation of endophlebitis in the splenic or mesenteric veins Post-operative indications are provided by signs of "silent" or inflammatory phlebitis in the leg, or by a marked rise in the platelet count (Tocantins, 1948).

Heparin is injected intravenously in doses of 50 milligrams every 4 hours, giving at the same time by mouth the more slowly acting dicoumarol in the dosage of 300 milligrams on the first day, and 200 milligrams on the second day. The heparin is stopped when the desired reduction of prothrombin reaches a level between 10 and 30 per cent of normal, estimated by comparing the coagulation time of normal blood with that of the patient after supplying his sample with optimal amounts of calcium, thromboplastin, and fibrinogen, that is, with all coagulating substances except prothrombin.

10. OPERATIONS

Operations on the spleen may be considered as follows: (1) splenectomy, elective, for small non-adherent spleens (for example in thrombocytopenic

purpura), for adherent spleens, or for large spleens, that is, those that protrude a hand's breadth or more below the costal margin; (2) splenectomy, emergency, for rupture; (3) occlusion of the splenic artery (temporary) as prelude to splenectomy for rupture; (4) ligation of the splenic artery as palliative substitute for splenectomy; and (5) short-circuit operations—spleno-renal anastomosis, porto-caval anastomosis (discussed under Liver—Cirrhosis, Vol. 5, p. 437) or mesentero-caval anastomosis.

(1) Splenectomy

(a) *The incision*

Paramedian incision

With proper relaxation any spleen can be removed through a paramedian incision which should begin at the left costal margin, 3 inches from the middle line, and reach a point 3 fingers' breadths below the caudal end of the spleen. The sole useful addition to this approach would be a transverse outward section of the abdominal wall. A transthoracic route is good in thoraco-abdominal wounds which penetrate the spleen. It should be recalled that the abdominal approach when large spleens are concerned carries in expert hands a steady 10 per cent mortality.

Transthoracic approach

(b) *Mobilization and delivery of the spleen*

Omentum may cover or bind the lower portion of the spleen which appears first, and there is a natural temptation to lift it by the tail. In large spleens however, the head should be delivered first.

(c) *Adhesions*

Adhesions to the dome of the diaphragm if they are frail may be easily broken with the fingers. Tough adhesions can be safely and quickly divided with the high-frequency current, keeping close to the spleen.

Danger of frail adhesions

Frail adhesions can be dangerous for although so easily broken as to give a treacherous feeling of security they may bleed persistently and the volume of blood lost may be only noticed when the spleen is out. Blood can be bailed from the abdominal cavity and filtered through two layers of gauze. Re-infusion of this blood is useful if there are haemorrhagic accidents.

(d) *Treatment of the pedicle*

The folds which lie to the front of the pedicle—gastrosplenic, pre-splenic, or other omental derivatives—do not themselves directly carry vessels to and from the spleen. They are, however, vascularized by offsets from the left gastro-epiploic artery. The lienorenal ligament includes the splenic vessels, and, with them the tail of the pancreas (Figs. 4–7). An approach to the splenic vessels through the back of the pedicle has the particular advantage that only a single layer of peritoneum separates the surgeon from the major splenic vessels; the tail, too, of the pancreas is at once seen and peeled uninjured off the spleen (Figs. 8 and 9).

...antage ...osterior

So great is the advantage of working from the back of the pedicle that even when a large spleen will not turn readily over, the small trouble of taking a seat on the patient's left and looking at the field from this low level will sometimes give surprisingly swift and dry splenectomies. A posterior approach however is not always possible.

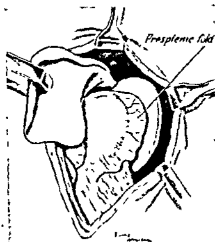


FIG. 4.—The presplenic fold: an occasional offset from the front of great omentum. It may increase the thickness of the pedicle (*see* Fig. 6).

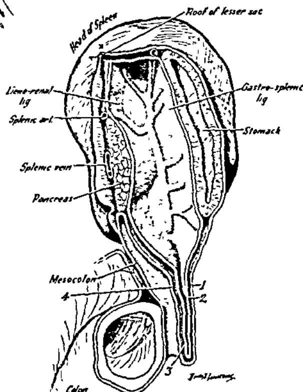


FIG. 5.—The left end of the lesser sac seen from within. The spleen here has a long pedicle (Fig. 7(*a*)); the blind end of the lesser sac—which enters the pedicle—"floats", therefore, with the spleen in the greater peritoneal cavity. The gastrosplenic and lienorenal ligaments surround the blind end, their four layers meeting at X in its roof. Traced caudally these four layers are continued into those of the great omentum—1, 2, 3, 4. A fold may go from X to the diaphragm—the phrenicosplenic ligament (*see* Fig 10).

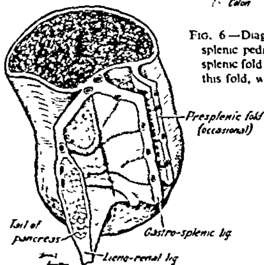
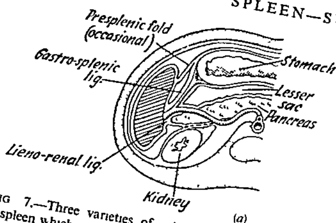


FIG. 6—Diagram showing the constituents of the splenic pedicle to the left of the stomach. A presplenic fold is seen adhering to the enlarged spleen: this fold, with the lienorenal ligament, constitutes a false pedicle carrying vessels derived from the left gastroepiploic vein and artery in addition to vasa brevia from the splenic trunks The layers of the lienorenal ligament here include the tail of the pancreas, and this ligament is called pancréaticosplenique in France Sessile spleens (Fig. 7(*c*)) have no lienorenal ligament. (*Modified from Patte, Lacase, and Dupret.*)



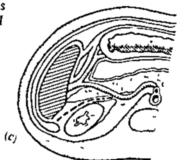


FIG 7.—Three varieties of splenic attachment· (a) The long-pedicled spleen which rotates on its long axis to the right and gives easy access to the back of the pedicle. Spleens, however, may be so large that axial rotation is checked by their own bulk. It is then that the surgeon can with advantage seat himself on the patient's left side in order to work on the back of the pedicle (*see* text) (b) The short-pedicled spleen; (c) the sessile spleen These last two types can only rotate after rupture or division of the parietal peritoneum The third type has no lienorenal ligament. (The dotted lines mark planes of embryonic fusion which are also planes of potential cleavage) These figures are all diagrammatic; they omit the thick fat and fusion of layers, which can make the anterior approach so difficult.

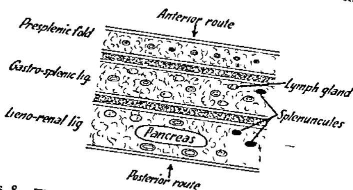


FIG. 8.—The anatomical club-sandwich Diagram of a splenomegalic pedicle seen in section The layers are thick with fat and caked together This diagram affords a contrast between the anterior and posterior routes of access to the splenic vessels. (Rings represent vessels)



FIG. 9—The pedicle approached from behind. The main vessels have been exposed here by dividing the single leaf of peritoneum which covered them—the posterior layer of the lienorenal ligament. This layer is often torn in mobilizing a short pedicled spleen (Fig 7); the vessels are then laid bare without dissection. (a) Tail of pancreas (*After Balfour*)

The veins of large spleens are often thumb-size and usually friable. No blind pass, therefore, should be made with any metal tool. The best instrument for finding unforcible passage is the index finger, whose gentle emergence is only counted safe when the true tint of the glove shows through a last coat of peritoneum. A curved forceps—passed back through the pedicle in contact with the retreating index—retrieves the ligature. It is seldom wise to clean these large veins too thoroughly before tying them; on this account they should never be tied with catgut, for the ligatures must be drawn tight enough (without fear of breakage) to hold the vein through tissues round it; silk or thread will do this best. Clamps are best reserved for the divided ends of these frail vessels. During a splenectomy, parenteral injection of adrenaline, before the pedicle is tied, will visibly contract the spleen, which thus surrenders blood that would be wasted. *Control of bleeding*

(e) The phrenicosplenic screen

This screen, when present, is an extension downwards of the phrenicosplenic ligament (Fig. 10), a widened, possibly tough, ligament which just fails to reach the horizontal shelf made by the phrenicocolic ligament. Entry can be

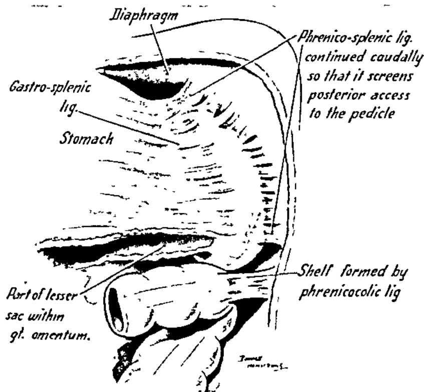


FIG 10—The occasional caudal extension of the phrenicosplenic ligament

made between these two ligaments (or through them, if they fuse) to the edge of spleen that meets the outer edge of the left kidney; there the plane of cleavage opens freely to the fingers working medially behind the screen.

(*f*) *Splenuncules*

These may grow after splenectomy. In operation for rupture they may be left to grow. All splenuncules should be removed in haemolytic jaundice and in essential thrombocytopenic purpura.

(*g*) *Stomach and pancreas*

The stomach is a special hazard in the posterior route. When the spleen is rolled to the right the gastrosplenic ligament winds with it and wraps the tense, thinned-out stomach to the upper end of the spleen. The stomach, mistaken for ligament, has been opened.

The anterior route for dealing with the pedicle will be used when a spleen is too large to be turned safely, or when its pedicle is so thinned out and so devoid of fat as to invite ligation of presenting vessels.

(*h*) *Derangement of the diaphragm after removing a large spleen*

Pulmonary collapse

Blind clamping may bruise or tear the left cupola, or the function of the diaphragm can suffer from relaxation due to loss of the splenic cushion. The liver often moves over and partly occupies the empty splenic bed so that the support of both sides of the diaphragm may be altered with the effect of favouring pulmonary collapse and subsequent pneumonia For this

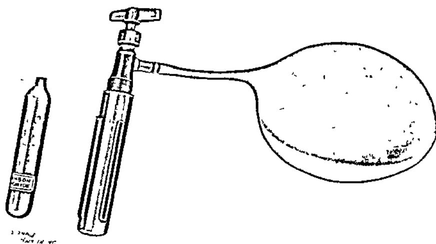


FIG. 11.—Rubber balloon attached to Sparklet resuscitator and partly inflated with CO_2 (A spare bulb is shown.) The balloon is designed to counteract the effects of relaxation of the diaphragm caused by suddenly removing the support of a large spleen The long tubular process projects through the abdominal wall for inflation or deflation

reason a child's balloon has been introduced into the empty splenic bed and inflated with oxygen. The slow shrinkage of the balloon gave the diaphragm time to adapt itself to the fall of tension and the balloon was withdrawn on the third or fourth post-operative day (Fig. 11).

(2) Emergency splenectomy for rupture

The surgeon dealing with these complex hazards, or (to leave the surgeon free) an assistant drilled on post-mortem material, makes a double grasp: he holds the hepatic pedicle between his left index finger put through the foramen of Winslow and his left thumb, while with his right fingers—unless the spleen is large enough to have too wide or thick a pedicle—he spans and kinks the splenic vessels (Bailey, 1930). *Temporary occlusion*

It is in dealing with the big unmanageable bleeding spleen whose gross fat-laden pedicle cannot be spanned or kinked by fingers that Mikulicz tampons find priceless use (*see* p. 5).

(3) Ligation of the splenic artery

The trunk of the splenic artery is most easily approached through the lesser sac, which can be opened bloodlessly by detaching the great omentum from the colon, lifting the omentum upwards and drawing the transverse colon downwards, thus avoiding injury to the gastro-epiploic or the middle colic arteries. The body of the pancreas is seen and its upper edge is defined. The splenic artery lies covered by that edge, and can be tied or closed provisionally.

11. CONCLUSION

The spleen is still, as Galen found, mysterious. Groups of disease on which splenectomy can count for most success provide discouraging exceptions, while other groups in which splenectomy generally fails admit sporadic cures. The groups, in fact, as measured by the yard-stick of this operation, are complexes that need analysis, like that begun for haemolytic jaundice and now in progress. Meanwhile, emerging patterns of blood disease supply new indications for splenectomy, alone or used with other means.

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STERILITY AND STERILIZATION

PART I

STERILITY IN THE MALE

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1. PREVENTATIVE MEASURES

309.] When the husband bears a large responsibility for the absence of children, it is more often because he is grossly infertile than because he is completely sterile, and subfertility is only exceptionally amenable to any form of surgical treatment.

By exerting pressure on the delicate tissues of the testis a hydrocele may be *Hydrocele* a factor in reducing fertility, but because hydrocele is usually secondary to some such lesion of the testicle as a low-grade infection, a radical cure of it will not necessarily be followed by a return to testicular health. Nor will the ligation of a varicocele improve the state of the seminiferous tubules, for, as *Varicocele* Corner and Nitch (1906) have shown, ligation of the pampiniform plexus is often followed by fibrotic or other degenerative changes in these structures.

Even the bringing down of an incompletely descended testicle will have little or no effect when it is undertaken in adult life. Carried out earlier, this operation is more likely to have satisfactory results. MacCollum (1935) found that an orchidopexy performed in a series of 89 patients, some 10–30 *Orchidopexy* years previously, gave a 61 per cent normality rate so far as fertility was concerned. This should be contrasted with a 10 per cent fertility rate in patients who had not previously undergone any operation. These figures clearly indicate that orchidopexy should be undertaken by the time of puberty whenever the testicles fail to descend spontaneously. Orchidopexy must be looked upon as being a prophylactic rather than a curative measure.

The surgical treatment of the orchitis of mumps is of a similar nature. The *Orchitis of mumps* pressure exerted by the exudation on the delicate germinal cells is often sufficient to destroy them within a few hours, and for this reason mumps is a frequent cause of male infertility. In all cases, particularly when the patient is past puberty and the swelling is bilateral, immediate steps must be taken

to relieve the tension in the swollen organs by means of multiple small incisions. The operation is best performed by delivering the swollen testis through a scrotal wound and stabbing it with a pointed tenotome in about a dozen places. A similar treatment of the epididymis has been recommended in cases of acute epididymitis in the hope of preventing subsequent occlusion of the epididymal canal. It may be objected that a haphazard puncture of the epididymis may itself sever the continuity of the epididymal canal, but experience has shown that the risk of this is less than is the risk of subsequent occlusion by fibrosis.

Acute epididymitis

There is yet another prophylactic measure against subsequent sterility, namely, the anchoring of a testicle which has given rise to symptoms of incomplete torsion. If the previous history of all cases of complete torsion of the testicle is carefully scrutinized, it will be found in a large number of cases that there have been premonitory symptoms in the form of pain, often following such exercises as cycling. These warnings should be accepted as an indication for preventative measures.

Anchoring of a testicle

2. DIAGNOSIS

Azoospermia in the male may be due either to aspermatogenesis or to failure on the part of the sperms to reach the semen. Obviously, it is only in the latter condition that surgical intervention will be of any avail. Sometimes the differential diagnosis between aspermatogenesis and a stenosis of the efferent canals is easily established; the testes are small and flabby in the former case, and in the latter there is an area of induration at the lower pole of each epididymis and a history of an attack of bilateral epididymitis. Sometimes the differential diagnosis can only be reached by means of a testicular biopsy.

Testicular biopsy

Anaesthesia

This operation can be performed either under local anaesthesia or under some such intravenous anaesthetic as Pentothal Sodium. Should the former be selected, the cord must be infiltrated in addition to the scrotum, as otherwise a sharp pain will be felt when the tunica albuginea is punctured.

Technique

The technique of the operation is very simple. The skin of the scrotum is kept stretched over the testis and an incision ½–¾ inch long is made in it. This incision is deepened until the white glistening covering of the testis is seen. The tunica is then stabbed with a pointed tenotome and a yellow button of testicular tissue will be seen to extrude from it. This small hernia of parenchymatous tissue is snipped off with iridectomy scissors and transferred immediately to a tube of Bouin's solution. Only if bleeding fails to stop with pressure is it necessary to insert a haemostatic stitch of catgut in the testis. In order to reduce the risk of subsequent haematoma, the patient should rest for an hour after the operation and should wear a suspensory bandage for a week.

Incision

Suture

3. TREATMENT OF ESTABLISHED STERILITY

(1) Vaso-epididymostomy

The lower pole of the epididymis is by far the commonest situation of a blockage in the efferent ducts of the genital system. In 1909 Martin devised

a short-circuiting operation to overcome this (Martin, 1922). Various changes have been made in his original technique, but for a time the results proved so disappointing that the operation was to a great extent abandoned. Hagner's paper in 1931 revived interest in the subject. Using the finest silver wire as suture material, he claimed to have obtained 19 successes in 31 cases. So far, Hagner's high percentage of cures has not been obtained by any other surgeon. Personally I employ Hagner's technique but combine it with the use of the Lespinasse retaining suture, which, in my opinion, maintains a close approximation of the epididymal canal with the new opening in the vas.

(a) Technique

The operation is performed as follows. The tunica vaginalis is opened sufficiently wide to allow of the testicle being easily delivered from the scrotum. A small ellipse is then excised from the supero-internal aspect of the globus major. If a milky fluid exudes from the incision it can be assumed, even without a microscopic examination, that this fluid contains spermatozoa and that the incision is beyond the obstruction. The vas is now isolated and a longitudinal incision is made in it at a site which allows of the incision in the vas being brought comfortably into apposition with the wound in the epididymis. A strand of silkworm gut is first passed along the lumen of the vas for about 20 centimetres in order to ensure that it is patent. The finest needle, such as is used for the suture of arteries, but threaded with the smallest procurable silver or stainless-steel wire, is then inserted as shown in Fig. 12. The needle is first passed through the coats of the vas about 4 millimetres distal to the longitudinal incision into the lumen and brought out of the wound. The needle then picks up a loop of epididymal canal, passes into the lumen of the vas again, through the incision, and finally emerges through its coats 3 millimetres proximal to the incision. When this retaining suture is drawn tight the wounds in the vas and the epididymis are brought into close apposition. Four anchoring sutures are next inserted through the epididymis and the vas, 2 lateral to and 1 at each end of the anastomosis. The distal end of the longitudinal retaining suture is cut short and the other end brought out of the neck of the scrotum and secured on the surface of the skin by means of a small piece of Elastoplast. The cutting short of the distal end facilitates the subsequent removal of this suture. The wound in the scrotum is finally closed without drainage. The testicles are raised

Vasal incision

Lespinasse retaining suture

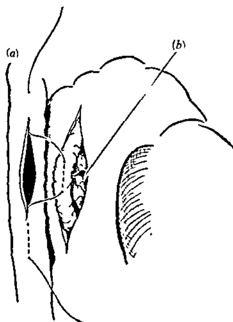


Fig. 12.—The insertion of the Lespinasse retaining suture. (a) Vas; (b) tubules of the epididymis.

by means of a pad of cotton-wool, supported by a perineal bandage, and the patient is returned to bed. Skin sutures are removed on the fifth day and the deep Lespinasse retaining suture on the ninth day.

Removal of sutures

(b) *Results*

The absence of spermatozoa in the semen when examined a month or two after the operation need not be accepted as an indication that the operation has necessarily been a failure. In some cases sperms do not reappear in the semen until 4 or 5 months later.

Danger of occlusion

It is unnecessary to stress the difficulties of this operation. Not only are the structures involved so small that the finest instruments and suture material have to be employed, but there is a grave danger of subsequent occlusion by fibrosis even when a temporary opening has been obtained. All that can be said of the operation is that it is the only possible method of remedying an otherwise incurable condition and that it is sometimes successful. It is difficult to supply any statistics by means of which its value may be accurately assessed, not only because it is an operation which is comparatively infrequently performed, but also because the surgeon is often left unacquainted with the final result. It would probably be true to say that the chances of success are about one in four.

(2) Removal of obstruction of the ejaculatory ducts

Difficulty of catheterization

Azoospermia is occasionally the result of occlusion of the ejaculatory ducts, usually the consequence of a previous attack of prostatitis. Diagnosis and treatment are both difficult owing to the fact that catheterization cannot be easily effected. The situation of the openings of the ducts on the verumontanum is indeed often such that it is mechanically impossible to introduce catheters. Even when the mouths of the ducts are more conveniently placed, catheterization may involve trauma, and trauma of such delicate structures is at all costs to be avoided. For this reason it is often preferable to reach a differential diagnosis by other means. One such means is to isolate the vas at the neck of the scrotum and to inject into it some such easily recognizable fluid as methylene blue, noting whether it does or does not escape into the posterior urethra. Another method is to inject an opaque fluid and to see whether the ducts are outlined in a vesiculogram. Sometimes injection of the vas acts also as treatment by forcing out from the ducts accumulations of inspissated or inflammatory material. This clearing of the channels may occasionally be brought about by a prolonged course of prostatic massage. No treatment has yet been devised for remedying obstruction due to organized tissue.

Methylene blue

Vesiculography

4. STERILIZATION

Sterilization has moral, eugenic and legal, as well as surgical, aspects and only the last named of these need here be considered. At the present time sterilization, for any other than therapeutic ends, would appear to be illegal in Great Britain, even when performed at the patient's request, but no surgeon who has carried it out has so far had to answer for his action in a court of law.

When for therapeutic reasons it is inadvisable for a wife to conceive, it is

definitely impossible, a condition that may be temporary or permanent." *Temporary sterility* Temporary sterility is sometimes physiological, as for example during lactation, when ovulation appears to be inhibited.

Relative sterility or relative fertility, intermediate between absolute sterility *Subfertility* and absolute fertility, may be simply called subfertility. The words "fecund" and "fertile", "subfecund" and "subfertile", "infecund" and "infertile" may be used interchangeably and, in this section, the word "sterility" will be avoided so far as is possible.

The condition of relative subfertility may be subdivided into primary subfertility, secondary subfertility, and dyskyesis or the inability to carry pregnancy to term.

Primary subfertility occurs in about 20 per cent of all cases of impaired *Causative factors* reproductive capacity. It may be caused by constitutional disorders, such as a pituitary deficiency in men, or by a genital hypoplasia or abortive menstrual (anovulatory) cycles in women.

Secondary subfertility is the group in which most cases will be found. The problem of male lowered fertility, which to present-day workers seems of ever-increasing incidence and importance, is considered in the preceding section. In the female it may be due to many causes, some physiological, some constitutional and some due to pathological processes.

Dyskyesis means the termination of pregnancy by abortion due to endocrine disturbance, or localized disease of the female genital tract, or by premature labour.

(2) Essential factors for reproduction

In the female Briefly the factors essential for reproduction are, in the female, the occurrence of ovulation, the patency of one or both Fallopian tubes, and the receptivity of the cervix to sperm. *In the male* In the male, in order that reproduction can take place the testes must produce normal spermatozoa, the male genital tract must allow the free passage of spermatozoa from the testes to the urinary meatus, and the prostato-vesicular secretions must be favourable to spermatozoa.

(3) Clinical groups of conditions found in the female

It will be found that most of the cases of subfertility referred for investigation fall into the following groups: pelvic lesions, either inflammatory or neoplastic; the cervical factor, the nature of the cervical plug of mucus and the reception of the inseminated spermatozoa; the tubal factor, which may be lack of function, spasm or occlusion; and the endocrine factor on the female side with its varying effects on the reproductive functions.

2. MINOR OPERATIVE MEASURES

(1) Treatment of dyspareunia and vaginismus

Dyspareunia The surgical treatment of dyspareunia is that of its cause. A fibrous or inelastic hymen should be excised; tender caruncula myrtiformes should be removed; an acute Bartholin abscess should be incised and drained, a chronic one excised when possible; any tender rectal condition should be suitably dealt with.

In some cases it will be sufficient to stretch the hymen digitally or with graduated dilators, with or without an anaesthetic.

Vaginismus

The milder forms of vaginismus often respond to local treatment, such as the application of an ointment containing a local anaesthetic. In more difficult cases an anaesthetic oil, such as Proctocaine, 4–8 cubic centimetres, may be injected close to the vaginal orifice. Operations for enlargement of the introitus are seldom performed nowadays. In true vaginismus, the syndrome is largely psychogenic, and therefore surgical intervention is not often indicated.

(2) Passage of a uterine sound

Many observers have wondered how much the therapeutic effect of a tubal insufflation may be due to the initial passage of the uterine sound. From time to time a series of cases has been presented in which the sole procedure has been the passage of a uterine sound. Thus, in an attempt to assess this "cervical-instrumentation" factor, Sharman (1948) has taken a series of 300 unselected consecutive cases. Of the 300 women, 240 were traced and 43 became pregnant. As 5 of these became pregnant at once, the conclusion is 38 (or 15·2 per cent) pregnancies resulted.

In every case the husband was tested at the same time, and, of the 300 men referred, 144 reported for seminal examination, 109 proved normal, 27 had major impairments, and 8 complete azoospermia.

Effect of tubal insufflation

The investigation is proceeding but from his other clinic figures Sharman concludes that tubal insufflation has twice the therapeutic effect of that of passing a sound.

(3) Dilatation and curettage, including endometrial biopsy

Dilatation and curettage is seldom indicated in the treatment of female sterility, whereas formerly it was almost a routine procedure. Probably the employment of curettage will gradually diminish still further and will eventually be restricted to certain conditions only, for example the presence of an unhealthy endometrium, in which the operation is positively indicated.

Endometrial biopsy

Endometrial biopsy has largely taken the place of curettage, and has proved to be one of the recognized ways of diagnosing the presence or absence of ovulation. For this there is no need for anaesthesia or hospitalization, except in a very few cases.

Dysmenorrhoea

When subfertility is associated with amenorrhoea or with menstrual irregularity, endometrial biopsy may have to be performed at any time in the cycle, and frequently repeated at intervals. It should be carried out a day or so before or on the first day of the actual loss. With the patient in the lithotomy position, a one-toothed volsellum is very gently applied to the cervix, avoiding any traction. Usually the biopsy curette will pass without the previous use of a uterine sound. The curette face is drawn down the middle of the anterior uterine wall and withdrawn, avoiding any pressure of the cutting edge against the wall of the cervical canal. The endometrial strip is then removed and a similar piece is taken from the posterior wall. The pathologist will then report on the section and the presence or absence of the secretory phase.

(4) Replacement of the uterus

Many workers consider that backward displacement of the uterus is of little importance as a cause of subfertility, provided that the tubes are patent and that there is no dyspareunia due to prolapse or tenderness of the ovaries. This position of the uterus may cause the external os to point up against the anterior vaginal wall, causing it to be out of immediate reach of the seminal pool. In such cases and again when the retrodisplacement is accompanied by pain on coitus, it is worth considering the replacement of the uterus and the

Hodge pessary

insertion of a Hodge pessary. If, despite this, pregnancy does not result and other marked infertility factors are not present in either partner, an operation to suspend the uterus by a shortening of the round ligaments will need con-

Laparotomy

sideration. Laparotomy is also indicated for those cases in which there is impairment of tubal function due to retrodisplacement, or to fixation of the uterus by adhesions or to suspected endometriosis.

(5) Uterotubal insufflation and hysterosalpingography

In 1920 Rubin first described his method of investigating tubal patency by means of intra-uterine inflation with oxygen. The principle of his method has been universally adopted, though many modifications of apparatus and technique have been developed through the years. One important adaptation

Kymographic method

has been the kymographic method originated by Rubin himself in 1925. Most workers nowadays use Rubin's own apparatus or Bonnet's, or Sharman's modification of Bonnet's.

The best time for insufflation is during the post-menstrual phase before the probable ovulation day, though some combine insufflation with the taking of an endometrial biopsy in the pre-menstrual phase. As it is usual to avoid anaesthesia, everything should be done to minimize the patient's discomfort.

Position of patient

Thus the complete lithotomy position may be modified to a dorsal position with the knees slightly flexed and the feet resting on the table, or the prone position with knees flexed may be adopted. A spasmolytic, such as nitroglycerin in tablet form, $\frac{1}{100}$ grain, may be given half an hour before. Other drugs such as Trasentin and amyl nitrite are being tried out. It is often a help

Leach-Wilkinson screw cannula

to use a cannula, such as the Leach-Wilkinson screw pattern, which dispenses with the volsellum. The chief function of the examiner is to maintain a gas-tight joint at the internal and external os.

The record on the drum may lead to an interpretation of normal tubal patency, when the gas most commonly passes through at a pressure of between 60 and 120 millimetres of mercury; or non-patency; or tubal spasm; or tubal stenosis, that is complete or partial stricture of the canals either by an internal or an external cause. The height to which the pressure may be taken and the number of times the test may be repeated on non-passage of the gas vary with different observers.

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30 years or over and the length of marriage 3 years or longer, when no other therapeutic measure was employed and the insufflation was done in the pre-ovulation phase; when no contraceptive precautions were taken for at least one year prior to the test; and when pregnancy follows within a month or at

most 2 months of insufflation, or pregnancy follows after repeated insufflation (a relatively lower pressure sufficing to demonstrate patency on a second, third or fourth test), or pregnancy follows the third month after one insufflation during which a high initial pressure was necessary and the tubes were found to be strictured or adherent. Rubin comments that when these conditions are satisfied the element of chance may be regarded as minimal.

Advantages of hysterosalpingography

Hysterosalpingography is usually considered to be complementary to insufflation, indeed, at times certain advantages are claimed, because it quite often proves insufflation results to be fallacious; sometimes the site of stenosis or occlusion is demonstrated, as in hydrosalpinx; it may disclose congenital or acquired malformations of the uterus; and because the possibilities of surgical relief may be better assessed.

The various types of radio-opaque oil are now being replaced by a water-soluble x-ray contrast medium or substance, such as Rayopake and Viskiosol 6. For these it is claimed that they have a viscosity similar to that of oil, that they are rapidly absorbed (often within 45 minutes) and rapidly excreted; that they render good delineation possible, and cause no pathological changes in the tissues.

(6) Operations on the cervix

The old-time operations for the so-called "pinhole os", as, for example, Pozzi's method for permanent enlargement of the cervical canal, are now seldom performed. Knowledge of the cervical function has markedly advanced with the post-coital test.

Cauterization

Cauterization is now usually performed without anaesthesia, and often at one sitting. The application of the volsellum and the insertion of the cautery blade within the cervical canal are the factors causing temporary discomfort. When, however, the cervical canal is small and a thorough dilatation is necessary to carry out efficient treatment, intravenous Pentothal Sodium is indicated, the patient usually being able to return home the same day. Radial cauterization by 6, 8 or 10 strokes is preferred to the surface coagulation method, Nabothian cysts being destroyed individually with the cautery point.

Destruction of Nabothian cysts

The patient should always be warned of the inevitable increase of the discharge, and of the chance of some bright bleeding occurring about the tenth to twelfth days, which only seldom is at all alarming. One month later the cervix should be inspected, a uterine sound being passed to prevent possible stenosis.

Conization

Conization of the cervix is less often performed in subfertile cases, as by it the cervical glands are completely destroyed, healing is usually very slow, haemorrhage after separation of the slough more likely, and subsequent stenosis of the canal more common. Crossen's recent follow-up of over 1,000 cases of wide conization of the cervix is a most important even if controversial contribution. In this he claims 91 per cent of cures, an absence of post-operative bleeding, 63 subsequent deliveries, 49 of these being first deliveries, and all without evidence of trouble from the conization (Crossen, 1949).

Amputation by various techniques may be indicated in some cases of congenitally elongated cervix, in cases of severe cervical erosion resistant to treatment and of cervical laceration hindering subsequent conception. In the

Trachelorrhaphy

last mentioned, however, the scar so often extends out to the vaginal vault that amputation is impossible and instead only a trachelorrhaphy or denudation of the lacerated area with suturing of these surfaces is at all practicable. These operations call for considerable hospitalization, often give rise to brisk haemorrhage, both primary and secondary, however careful the technique and haemostasis at the time, and so should be carried out only in carefully selected cases of subfertility.

3. INTERMEDIATE OPERATIVE MEASURES

(1) *Uteroscopy and peritoneoscopy*

Uteroscopy has not as yet proved to be reliable, or had many exponents. Peritoneoscopy has a certain place in the elucidation of subfertility problems, the largest series reported being by Palmer (1940) of Paris, Ruddock (1939) and Shackelford (1944) in the United States of America. At this investigation the size and shape of the tubes, the existence of hydrosalpinx, a tuberculous salpingitis and the condition of the ovaries are the more accessible diagnostic features. The examination is usually conducted under morphine and a local anaesthetic with the patient in the Trendelenburg position.

Anaesthesia

(2) Culdoscopy

TeLinde (1946) has found that peritoneoscopy is frequently disappointing owing to the loops of bowel being troublesome or to adhesions from previous operations, and he now prefers culdoscopy. For this procedure the patient is put in the knee-chest posture and either intravenous Pentothal Sodium is administered or a local anaesthetic is used at the site of puncture of the trocar, not too close to the cervix posteriorly, into the cul-de-sac. As soon as the obturator is withdrawn there will be an audible inrush of air if the tip is in the cul-de-sac. The sterile culdoscope is then introduced through the cannula, and so never touches the vaginal mucosa, thus reducing the possibility of infection to nil.

Position of patient

TeLinde has improved his technique of culdoscopy, claiming that "the uterus, tubes, ovaries, broad ligaments, utero-sacral ligaments, infundibulo-pelvic ligaments, rectal wall, sigmoid, small intestines, and often the caecum, appendix, and ureters can be visualized". In this way the condition of closed tubes and the likelihood of opening them by plastic surgery may be noted; or the role of the ovary may be evaluated by observing follicles and corpora lutea as well as the presence and character of peri-ovarian adhesions.

4. MAJOR PROCEDURES BY LAPAROTOMY

(1) Operation for retroversion of the uterus

When it is decided that retroversion of the uterus must be treated to help conception or to avoid further miscarriages a modified Gilliam's operation is usually the method of choice. Occasionally the Alexander Adams extra-peritoneal operation or the Baldy-Webster sling technique may appear preferable.

Modified Gilliam's operation

(2) Myomectomy

When fibroids are regarded as being responsible for subfertility they should be removed by myomectomy (*see* Uterus—Fibroids).

(3) Operations on the ovary

Before the decision to open the abdomen is made in these cases, all aspects should be most carefully discussed with both the husband and wife. Other subfertility factors that may coexist should be assessed, and the risks of laparotomy, the presence of any underlying pathological lesion that tends to handicap the plastic work that is necessary, the small chance of success and the risk of subsequent abortion even if conception occurs, must all be methodically examined.

(*a*) *Cystectomy*

At cystectomy, the technique of which has been perfected by Bonney, conservative operations which previously would not have been deemed worth while or justifiable are now performed on the ovary.

(*b*) *Intra-uterine implantation*

Intra-uterine implantation of the ovary is usually performed by some modification of the Estes technique, a part or the whole of the ovary being implanted into the uterine cavity through an opening made through the uterine wall, though with very little subsequent success.

(4) Salpingolysis

Salpingolysis is the term used to describe the release of adhesions about the fimbriated ends of the tubes. When this has been carried out, the tube should be carefully examined and a retrograde inflation with a rubber bulb and fine cannula should be done very gently to see if the air passes easily up the tube and into the uterus. Catgut or allantoic membrane may be inserted in order to prevent subsequent occlusion.

(5) Salpingostomy

Salpingostomy, aiming at the restoration of a free passage through the tube, should be used only as a last resort.

It is probable that the total average of success from all methods of salpingostomy is not greater than 9–10 per cent, but the introduction and use of antibiotics should gradually reduce the number of cases of acute and chronic tubal disease, and so tend to avoid much disappointing tubal surgery. The administration of antibiotics pre-operatively and post-operatively in certain cases is also likely to produce better end-results.

Greenhill (1937) in his 818 cases of tubal surgery from various sources found only 54 pregnancies. He stresses very careful selection; the patient should be under 35 years of age, she must have at least one functioning ovary, both tubes or the only tube present must have been proved to be closed, there must be no other cause for the subfertility than tubal closure, there must be no gonorrhoeal, post-abortal or tuberculous infection in the genital tract, and the patient must be a good surgical risk with a fertile and healthy husband.

When an exploratory operation has been decided upon it may be found that

Occlusion at the fimbrial end

the occlusion is at the fimbrial end, or in the outer third of the tube. Sometimes a depression marks the point of closure of the tube, and it may be enough to insert the point of a fine pressure forceps to milk out the contents of a hydrosalpinx, and to oversew with a fine catgut suture, again inserting a catgut or allantoic membrane. At other times the end portion of the tube calls for resection, when the most suitable technique is the "circumcision cuff" method. Here the opened-up fimbrial end is folded back over a special Bonney forceps, a small rubber catheter being then passed into the lumen of the tube, the forceps being released and the serosal edge of the cut tube sewn back on to the peritoneal surface, so as to form the cuff. The catheter is then removed and the tube tested for patency. In such cases it is often wise to suspend the tube and ovary to the pelvic peritoneum and, if there is a retroversion of the uterus, to shorten the round ligaments. In addition to catgut or allantoic membrane being laid in the new ostium to prevent further adhesions, strips of amnion removed from cases of Caesarean section, after being soaked in saline solution and preserved in absolute alcohol have recently been tried with success (Snaith, 1948). Rommer (1948) cuts 4 longitudinal ribbons $\frac{1}{8}$–$\frac{1}{4}$ inch long at the fimbria, peels them back and anchors them with fine chromic catgut, attaching the ovary to one of these ribbons.

Occlusion in middle of tube

If the occlusion is in the middle of the tube, the site is first localized by air insufflation with a small glass or metal syringe passed into the fimbrial opening. One method is to attempt a resection with an end-to-end anastomosis, a strand of catgut being passed through the junction to maintain continuity. This is probably the least favourable site for operative treatment, so that many prefer to carry out an intra-uterine implantation, using the healthy part of the tube.

Occlusion at uterine end of tube

For blockage at the uterine end of the tube, re-implantation of the healthy tube into the uterus may be tried. Whatever technique is used, after the occluded portion of the tube has been excised, the proximal end of the healthy tube is brought through an opening in the uterine wall into the cavity. A wedge-shaped piece of tissue is excised in the cornu, or a circular core is reamed out with a special circular movement, avoiding the vascular tubal angle, and the tube, after being split for about 1 centimetre, is brought into the cavity; fine catgut sutures are then passed through the uterine muscle, fixing the ends of the tube and closing the uterine opening. Great care should be taken in avoiding tension of the pedicle of the tube and in securing ultimate haemostasis. Sometimes a strand of silkworm gut, or silver wire size 16–22, or a ureteric catheter, has been threaded through the tubal lumen and then pulled through the cervical canal from below, being subsequently removed from below some time after operation. If the patient has a normal temperature post-operatively a gas insufflation is advised 5 and 14 days afterwards. The chief difficulty is that however satisfactorily the operation may proceed at the time, subsequent adhesions may cause further occlusion, despite repeated insufflation.

Haemostasis

Green-Armytage (1949) states that:

Hysterosalpingograms

". . . the study of Hystero-salpingograms demonstrates that the site of occlusion after induced abortion, or puerperal sepsis, is most often at the cornua; whereas in practically all other types of infection, it is in the whole length of the

tube, and particularly is this so in the case of gonorrhoea, *B. coli*, and tuberculosis.

"This finding is of the greatest value, for if the history and the x-rays indicate that the block is at the cornua, then on laparotomy one will almost invariably find that the distal two-thirds of the tube are perfectly healthy and patent. Therefore, if the fibrous occluded portions at the cornua can be excised, then each distal healthy part of the tube can be implanted into the uterus by a technique not dissimilar to that used when transplanting ureters into the colon, the only point of importance being that it is necessary to excise the cornua completely in order to ensure success.

"In some cases one has to make a coronal incision from cornu to cornu before one can satisfactorily implant the tubes

"Out of 39 patients operated upon by this method to date, 4 have become pregnant and gone to term; 1 has aborted.

"Such poor results after time-taking surgery, which must include a follow-up 6 or 8 weeks later by a carbon dioxide kymograph test, are admittedly disappointing, but I feel sure that as technique improves and more cases are tackled conscientiously and scientifically, results will be better. Indeed, I am of the opinion that the end results of this type of operation are better than those in which the tubes are distended with water or completely glued at the fimbrial ends, for in these although salpingostomy or a cuff operation is easy, the ostia tend to reclose and/or the epithelium and muscle fail to transmit the ovum In two recent cases of mine of this nature extra-uterine gestation has occurred

"Of course the best results are to be expected from that type of case where the tubes are in that state which is spoken of as 'phimotic', that is the fimbriae are turned in or lightly glued together, the result of some low-grade inflammation, e g. appendicitis. In some others it will be observed that the oil or Rayopake extravasates with difficulty from the fimbriae and appears to be held up in a sort of mosquito curtain which is made up of veils of peritoneum, the so-called serocele. Either of these surgical problems, which are by no means rare, can be solved by salpingolysis. In these, the expectation of success should be between 20 and 30 per cent, provided that all patients are conscientiously followed up by one or more carbon dioxide tests using a kymograph."

(6) General conservative pelvic surgery

It has come to be fully understood at the present time that the gynaecologist should spare no pains to carry out as conservative surgery as possible on the uterus or tubes or ovaries in a woman of child-bearing age.

Endometriosis

The association of endometriosis with retrodisplacement of the uterus has been noted for some time. In Beecham's series, the incidence of retrodisplacement was 42·5 per cent, the utero-sacral ligaments being involved in 91·3 per cent of the patients, and 72 7 per cent showed ovarian lesions (Beecham, 1946). In all these cases the Baldy-Webster sling technique was used to correct the retrodisplacement, and with conservative surgery child-bearing capacity was retained in 52 5 per cent.

5 STERILIZATION

Once sterilization has been decided upon, the operation may be performed by either the abdominal or the vaginal route.

(1) Abdominal route

Methods

By the abdominal method, the object of sterilization will be either temporary, the abdominal ostia of the tubes being buried between the layers of the broad ligament, or permanent. There are several methods in use, when

either cornual excision or local tubal excision is employed. The burying of the stump of the tube and complete haemostasis are of great importance. Crushing and ligation of a small knuckled portion of the tube which is picked up with a forceps has been extensively used. On other occasions salpingectomy with burying of the stump, or hysterectomy, depending on the condition found at operation, may be the method of choice. Post-partum sterilization has its place among other methods, as the patient is already in hospital. Whiteacre (1946) in his series of 150 cases, advises the operation within 1–2 hours of a spontaneous delivery, through a 1½-inch incision below the umbilicus, the knuckled tube that is picked up with the forceps being carefully and thoroughly crushed, and ligated with double heavy silk.

(2) Vaginal route

When the operation is performed by the vaginal route an opening is made through the anterior or posterior fornix, and the Fallopian tubes are crushed or tied or divided.

Electro-cauterization

Electro-cauterization of the tubal opening into the uterus has had its advocates, but it is not now considered to be a satisfactory procedure, as a tubal insufflation has to be repeated every 6–12 months and, furthermore, a number of subsequent pregnancies has been reported.

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[References to other titles are given under Sterility and Sterilization in the Index Volume. The subjects are also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 11, pp. 447 and 467.]

STERILIZATION OF SURGICAL APPARATUS

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1. VARYING PRACTICE

311.] The sterility of surgical apparatus has been so much taken for granted for so many years that few surgeons are in the habit of inquiring closely how this condition is supposed to have been achieved. The theatre sister is usually the repository of knowledge and tradition in this subject, and practices originally laid down by individual surgeons, or perhaps by the manufacturer of a particular piece of apparatus, form a ritual which varies widely from one hospital to another. Ecker and Smith (1937) circulated a *questionnaire* on this subject to 207 leading hospitals in the United States of America, receiving 106 replies, showing great diversity of practice, including the use of some methods which were plainly inefficient; for the sterilization of sharp instruments alone 15 different methods were used, 11 being chemical and 4 employing heat in different forms (boiling, autoclaving, hot air, and hot oil). There is similar diversity in the methods used in Great Britain and in other countries. In these circumstances it is difficult to be dogmatic in advocating particular

methods. It may nevertheless be of some service to define underlying principles, and to indicate by what means sterility can with certainty be achieved. How far these are applicable in practice often depends on two other considerations, the time available, and the destructibility of the article to be sterilized.

2. RELATIVE AND ABSOLUTE STERILITY

Sterilization is an absolute term and should be used only of a process capable of destroying all forms of bacterial life. Many of the proceedings here concerned are not so capable. They may be perfectly satisfactory for destroying *Pyogenic cocci* pyogenic cocci and other ordinary bacteria; these are killed by only moderate heat and, as a rule, by comparatively weak solutions of the more efficient *Sporogenous bacteria* chemical disinfectants. On the other hand, sporogenous bacteria will survive boiling and withstand immersion in strong solutions of many disinfectants for periods varying from several hours to many years. The answer to many questions depends on whether the method used has to be capable of destroying spores as well as vegetative bacteria.

3. SPOROGENOUS BACTERIA

(1) Distribution

There are two genera of sporogenous bacteria which are respectively obligate *Bacillus* aerobes and obligate anaerobes. The former genus, *Bacillus*, contains only one pathogenic species, *B. anthracis*: its non-pathogenic members, such as *B. subtilis*, are widely distributed in nature, and on account of their high heat-resistance and harmlessness, are convenient objects to employ in tests *Clostridium* of sterilizing efficacy. The anaerobes of the genus *Clostridium* include *Cl. tetani* and *Cl welchii* and other species concerned in the production of gas gangrene. These are also widely distributed; they are normal inhabitants of the lower intestine of man and other animals, and exist in profusion in soil and dirt generally. They may also be found in manufactured products, notably those derived from vegetable sources, such as paper and wood-wool, but including anything, whether a powder, a liquid, or a solid object, which can have been exposed to dirt or even atmospheric dust.

(2) Clostridial infection

There can be no doubt that the spores of Clostridia are frequently present in imperfectly sterilized surgical materials and even gain access to the tissues, *Reasons for rarity* usually without doing any harm. There are three reasons for the rarity of these anaerobic infections, despite their omnipresent danger and the imperfection of the precautions taken against them. Not all species are pathogenic; among those that are, toxigenicity is very variable—this is particularly true of *Cl. welchii*; thirdly, and most important, these spores are incapable of germination in healthy tissue. The factors which tend to lower oxygen tension and thus predispose to gas gangrene in an accidental wound, are all absent in a clean surgical wound. Gas gangrene is uncommon enough in consequence of gross accidental trauma accompanied by soiling with dirt: what wonder that it should be still more rare after the comparatively minor injury of operation with a contaminated instrument? Yet it does occur; it has even been

known to follow hypodermic injection. In such a case the drug injected is commonly of a nature to supply the missing factor: adrenaline, for instance, lowers oxygen tension by its local vaso-constrictive effect. *Adrenaline*

4. METHODS OF STERILIZATION

In view of the facts mentioned, it is quite a tenable proposition that sterilization need not be absolute; that for all ordinary purposes mere freedom from such organisms as streptococci and coliform bacilli is all that is needed. On the other hand, it must be agreed that if absolute sterilization is feasible—certainly if it is equally convenient—it is to be preferred. Throughout the consideration of individual methods of sterilization that follow, it is therefore necessary to ask: is the material to be sterilized possibly contaminated by sporogenous bacteria, and will the method proposed destroy them?

(1) Heat

There are obvious reasons for preferring heat to other methods of sterilization whenever it is applicable. Its effects are precisely known and it is capable of exact regulation. Properly employed, it is certain in its effect: it is expeditious, cheap, clean, and harmless to many materials. It can be used in several ways. *Advantages*

(a) *Moist heat: the autoclave*

Although the thermal death-point of bacterial spores is above the temperature of boiling water (100° C.) it is not far above this: some species are killed at 105° C. and all but occasional and exceptional nonpathogens at 115° C. (moist heat). These figures apply to exposure to the full temperature for a period of about 20 minutes, and these conditions are readily attained by means of steam under pressure. The autoclave is a strong, insulated metal vessel, usually of cylindrical shape, with an aperture which, when closed by multiple screws, is gas-tight, into which steam is admitted (or in which it is generated) until a gauge records that the desired pressure has been attained: it is then maintained at this level for the desired period. *Effective temperature* *Description*

(i) *Effect of air retention.*—The efficiency of autoclaving is by no means a foregone conclusion, as some people regard it. One reason for this is that pressure is not necessarily an indication of temperature, and it is temperature that matters. Pressure can be exactly translated into temperature if the atmosphere consists of pure steam, but too often the atmosphere in an autoclave includes a substantial proportion of air. Ideally this should be entirely expelled before the pressure is raised, and in the laboratory type of autoclave this can be done by first blowing the air out through a cock provided for the purpose when the steam is first turned on. Provision is made for this in surgical autoclaves by fitting a vacuum extractor operated by a steam jet: this rarely reduces the pressure in the autoclave to less than one-third of atmospheric. Allowance must therefore be made for the diminished temperature resulting from the presence of this residual air. The following Table, quoted from Underwood (1934) enables this reduction to be calculated. *Air expulsion* *Surgical autoclaves*

(ii) *Packing of drums.*—If an adequate temperature (not merely pressure) is maintained in the autoclave for a sufficient length of time, failure can be

due only to imperfect penetration by steam of the materials to be sterilized. This is unfortunately only too common; the drums in which the materials are contained [illegible]

[illegible] or occlude apertures permitting the access of steam, is far from ideal from this point of view; it is much safer to pack the materials in fabric bags. In either case, packing must be loose; to stuff a drum as tightly as possible is expecting too much. For the same reason—the necessity for free access by steam—individual units, whether drums or packages, should not be stacked closely together in the autoclave. Impermeable wrappings such as Cellophane are inadvisable.

TABLE

TEMPERATURE WITH VARIOUS DEGREES OF AIR DISCHARGE

GAUGE PRESSURE IN POUNDS	PURE STEAM COMP. AIR DISCHARGE		$\frac{2}{3}$ AIR DISCHARGE (20" VACUUM)		$\frac{1}{2}$ AIR DISCHARGE (15" VACUUM)		$\frac{1}{3}$ AIR DISCHARGE (10" VACUUM)		NO AIR DISCHARGE	
	Deg. C	Deg. F.	Deg C	Deg F	Deg C	Deg F	Deg. C.	Deg. F.	Deg. C.	Deg. F.
5	109	228	100	212	94	202	90	193	72	162
10	115	240	109	228	105	220	100	212	90	193
15	121	250	115	240	112	234	109	228	100	212
20	126	259	121	250	118	245	115	240	109	228
25	130	267	126	259	124	254	121	250	115	240
30	135	275	130	267	128	263	126	259	121	250

Time factor

(iii) *Autoclaving liquids.*—In sterilizing liquids by autoclaving the time factor is important, since it takes much longer to raise a bulk of liquid to the temperature of its surroundings than to produce the same change in a permeable material. A safe rule is to allow an extra 20 minutes per litre of liquid in each vessel; in practice the volume will rarely exceed this.

Automatic recorder

(iv) *Tests.*—Autoclaving efficiency should be regularly checked. Large installations are fitted with an automatic recorder charting air discharge and pressure maintenance; these charts furnish evidence that the autoclave is being correctly operated. This, however, is not enough; proof is needed that the required temperature has been attained and maintained within the material to be sterilized, for instance, in the centre of the contents of a drum. Many objects have been used for this purpose, of which the first to be used was an egg: if it came out hard-boiled the operator was satisfied. Tubes containing substances of different melting points, and ampoules of a liquid which changes colour from red through yellow to green, take inadequate account of the time factor. Much the best indicator is a permeable package containing living bacterial spores, whether in the form of a dried spore suspension of such an organism as *B. subtilis*, or of dried soil, dust, or other known spore-containing material. Simple cultivation of this will prove or disprove the efficacy of the run in the most conclusive and appropriate way. Anyone who has had much experience of doing such tests knows that positive cultures are often obtained, at least when the method is first introduced and before its lessons have been learned. Inefficient autoclaving rarely

Bacterial indicator

Conclusive proof

does harm because the previous laundering of such articles as towels and gowns is sufficient to rid them of all ordinary pathogenic bacteria.

(v) *Rules for autoclaving.*—It is difficult to lay down hard and fast rules as to times and pressures in autoclaving, for reasons which should be clear from what has already been said. For general purposes a temperature of 115° C. (240° F.) should be aimed at, and maintained for at least 30 minutes if a large bulk of material is being treated, or for 20 minutes if small objects, such as instruments, are concerned. Owing to the perishability of rubber at such temperatures, gloves are usually autoclaved at a lower pressure, a theoretically rather unsatisfactory compromise which nevertheless seems to serve its purpose.

Temperature for general purposes

Perishability of rubber

(vi) *Materials to be autoclaved*—Autoclaving is unquestionably the proper method of sterilizing the following materials, which will therefore not be mentioned further.

Fabrics, such as gowns, towels, swabs, dressings, and anything composed of similar material.

Watery liquids, including distilled water, saline and other solutions must be autoclaved; it is a dangerous fallacy that water is sterile merely because it is distilled. The liquids should be in sealed bottles, the remaining contents of which are discarded after first use. Neglect of these precautions is the usual cause of meningitis following lumbar puncture or spinal anaesthesia (Garrod, 1946).

Meningitis

Rubber articles, such as gloves and tubing; autoclaving may not always be necessary for repeated sterilization of certain of these, such as catheters.

Composite apparatus, including glass, rubber, and possibly a liquid, such as a transfusion set, should be sterilized in the autoclave.

(b) *Dry heat*

A method depending on penetration by steam is obviously inapplicable to anything not so penetrable. An oil, for instance, is immiscible with steam; its sterilization is therefore governed by the law applicable to dry heat. This may be stated as follows: that, in contrast to moist heat, a temperature about 40° C. higher must be applied for about twice the time to achieve the effect. Thus absolute sterilization by dry heat requires the maintenance of a temperature of about 160° C. for one hour. This is obtained in an oven heated by gas or electricity, preferably the latter, and fitted with automatic control. It should be verified that all parts of the oven attain this temperature. This piece of apparatus is essential in a bacteriological laboratory, where it is mainly used for glassware of all kinds; it might with advantage be a more regularly used piece of surgical equipment also.

Oils

Temperature and time

Materials to be sterilized by dry heat.—Dry heat is required for sterilizing the following articles.

Oils, such as liquid paraffin or other liquid oils, Vaseline in any form (including Vaseline gauze), and bone wax.

Dusting powder for gloves and sulphonamide powders for local application (these are caked by exposure to steam; if they are autoclaved in a sealed vessel the dry-heat law applies and the temperature attained is inadequate).

These are absolute indications for dry heat, but the method is also applicable with advantage to certain instruments, particularly syringes.

(c) *Boiling*

Non-sporogenous bacteria

The third principal method of using heat is boiling. This is the quickest and most reliable way of destroying non-sporogenous bacteria: these, indeed, are killed in less than one minute at temperatures considerably lower, and the practice of boiling for fixed periods of 5, 10, or even more minutes has no rational foundation. The only reason for prolonging the process at all is to enable heat to reach the interior of a syringe or to communicate itself fully to some bulky solid instrument.

Formalin

Sodium carbonate

Disinfectant solutions.—The objection to boiling is that it cannot be relied on to destroy spores. It will, however, do so if a chemical disinfectant, which itself may be quite inadequate for the purpose under ordinary conditions, be added to the water. Weak formalin has often been used in this way: its volatility is an objection. Much the best substance to add to the water is sodium carbonate in a concentration of 2 per cent. Boiling for 5 minutes in this solution can be depended on to ensure absolute sterility. The effect of the solute is not due to raising the boiling point of the water; a specific chemical action on bacteria is added to that of heat.

Simple boiling will therefore serve for any instrument uncontaminated by sporogenous bacteria, such as a syringe reserved exclusively for aseptic uses. It can be made universally efficient only by chemical addition.

(2) Chemical means

It is in the use of chemical methods of sterilization that practice is most diverse and sometimes unsatisfactory. The first necessity is an appreciation of the properties of the reagents commonly used; these fall into four principal classes.

(a) *Phenols*

Phenol itself and cresols (usually in the form of Lysol) if used in adequate strength (5 per cent and 2 per cent respectively are adequate) in watery solution kill ordinary bacteria rapidly: exposure for 5 minutes is ample. Lysol is very much less active if diluted in spirit; a 10 per cent solution in spirit failed to disinfect in 10 minutes a scalpel blade thinly smeared with staphylococcal pus, although a watery solution of the same strength did so in 1 minute. Disinfectants of this nature will not kill spores, this has been confirmed by Spaulding (1939) in *ad hoc* experiments directed to the present subject.

(b) *Spirit*

Disinfection times

Alcohol is rapidly bactericidal only when diluted with water, the optimum concentration being about 75 per cent by volume. The disinfection times determined by Gregersen (1915-16) for dried staphylococci immersed in different concentrations of alcohol were as stated below.

Alcohol, per cent	*Time in minutes*
60	1·5
70	0·75
75	0 63
80	2
85	5
90	22
95	270
99	2-7 days
100	more than 7 days

This action is exerted only against non-sporogenous bacteria. Alcohol has no effect whatever on spores; commercial spirit may indeed contain them in a living state.

(c) *Mercury salts*

There is much spurious information about the bactericidal action of mercury salts and compounds, due to failure to neutralize the disinfectant in cultures made to determine whether it has acted in a given time. Mere traces have a strong bacteriostatic action in simple media, and bacteria consequently appear to have been killed when in fact they have not. Failure to recognize this has vitiated the work of scores of investigators, from Koch himself almost to the present day.

Slowness of action

The outstanding feature of the action of mercury salts is its exceeding slowness. This was clearly demonstrated in the last century by the classical studies of Krönig and Paul (1897), who showed that the numbers of living bacteria immersed in solutions of these salts underwent a gradual diminution over a period of several hours. Spores and vegetative bacteria are killed, but the former much more slowly than the latter. Mercury perchloride is much the most active salt, and the least applicable owing to its corrosive action. Mercury biniodide is very much less active; in a recent experiment, using the technique of Kronig and Paul, with *Staphylococcus aureus* as test organism, a 0·1 per cent solution had no evident effect in 1 hour, caused a progressive diminution in survivors at 2 and 4 hours, and achieved sterility in 6 hours. This period of exposure had no effect at all on spores. Mercury oxycyanide is intermediate in activity, and various organic mercury compounds behave similarly.

Perchloride

Biniodide

Oxycyanide

Minimum periods of immersion

It is exceedingly doubtful whether these substances have any proper place in surgery. If they are to be used for sterilizing instruments or other objects, minimum periods of immersion should be 2 and 6 hours respectively for the perchloride and biniodide.

(d) *Formalin*

Solution

Formaldehyde, whether in solution or as a vapour, is one of the most useful of surgical disinfectants. It is commonly used as a solution, to which borax is added in order to prevent rusting, for the storage of sterile instruments. The composition of this solution in the *British National War Formulary* is:

Borax	15 g.
Solution of formaldehyde	25 ml.
Phenol	4 g.
Water to	1,000 ml.

Absolute sterility

It is not sufficiently recognized that this solution will produce absolute sterility as well as maintain it. Formalin is not a rapidly acting disinfectant, and the time allowed for the destruction of non- sporogenous bacteria should be 30 minutes and for sporogenous 24 hours.

Other formulae of the same type contain higher concentrations of formalin and sometimes of alcohol. Two such solutions were the only ones out of 7 tested by Spaulding (1939) which sterilized scalpel blades contaminated with sporogenous bacteria.

5. STERILIZATION OF PARTICULAR MATERIALS

In the light of the facts previously stated, it is now possible to consider the sterilization of certain articles not clearly falling into the categories already specified, which call for treatment by moist and dry heat.

(1) Steel instruments

The sterilization of ordinary instruments—particularly sharp instruments, which are said to be blunted by heat in various forms—is the central problem in this subject. Boiling, or immersion in spirit or a solution of phenol or Lysol, will destroy ordinary but not sporogenous bacteria, and it should be remembered that any operation on the lower bowel contaminates the instruments with the latter.

Methods for absolute sterility

If absolute sterility is required, the methods available are autoclaving, dry heat at 160° C., boiling in 2 per cent sodium carbonate, or prolonged immersion in a formalin solution. Local circumstances may determine which of these is the most convenient.

Continental practice

Dry heat is extensively used on the Continent, the entire set of instruments required for any operation being so treated in a closed tray.

Prevention of oxidation

It may be remarked that if this were rendered air-tight, and filled with an inert atmosphere, oxidation would be precluded and damage by heat to cutting edges would presumably be impossible. Such sets can be kept indefinitely until required

Disadvantage

The drawback of this system is that it requires a large stock of instruments

(2) Syringes

Owing to the crevices which exist in the interior of a syringe, particularly of the Record type, no chemical method can be relied on to sterilize it (Medical Research Council, 1945). Syringes should preferably be of the all-glass type, sterilized by dry heat, and enclosed in tubes in which they are protected from contamination until required for use.

(3) Suture materials

Linen and silk thread, as supplied commercially, are usually contaminated with sporogenous bacteria, and although these are usually non-pathogenic, it will generally be conceded that they are better destroyed. Neither boiling nor immersion in 5 per cent phenol will achieve this These materials should

Autoclave

be autoclaved; provided that they are not wound tightly on spools this causes no damage. Ecker and Smith (1937) made numerous accurate estimations of the tensile strength of silk before and after autoclaving and found no difference. Silkworm gut and horsehair are treated in the same way.

(4) Catgut

Raw catgut (as distinct from catgut sterilized during manufacture) presents a special problem, since it is naturally liable to contain Clostridia, notably *Cl. tetani*, and is spoiled by heat, whether moist or dry, adequate to destroy these. Only one disinfectant is known which will achieve the difficult task of penetrating this dense material and destroying resistant spores within it. This is iodine in watery solution only: the inclusion of spirit causes it to fail.

Claudius solution

The Claudius solution is generally used: this consists of iodine 1 gramme, potassium iodide 1·5 grammes, and water 100 millilitres; catgut should be

immersed in it for 7 days. Post-operative tetanus has frequently been attributed in the past to raw catgut treated by methods, such as immersion in 5 per cent phenol, which are demonstrably quite ineffective (Bulloch, Lampitt and Bushell, 1929).

(5) Catheters

Sporogenous bacteria rarely infect the urinary tract, and methods of sterilization for catheters need therefore not be such as to destroy them. Rubber catheters can be boiled; silk-web and other perishable materials are best sterilized in formaldehyde vapour. This must be blown through the catheter; it cannot be expected to diffuse throughout the length of a narrow tube.

(6) Cystoscopes and similar instruments

Cystoscopes and many similar instruments, such as peritoneoscopes and bronchoscopes, are difficult to sterilize owing to the variety of materials of which they are composed. Designers of new instruments, particularly those including uncommon and easily destructible materials or those having electrical connexions, might with advantage bear this aspect of their use in mind. Formaldehyde vapour is usually the only possibility, its free access to every part required to be sterile must be assured.

(7) Anaesthetic apparatus

The face-piece at least of anaesthetic apparatus—if not the tubing, in which secretions and bacteria are apt to accumulate—should be sterilized after use on each patient, whether suffering from a communicable disease such as tuberculosis or not. If any disinfectant is used, it is apt not to be entirely washed off afterwards, and to damage the face of the next patient; rubber tends to absorb such liquids, and hence quite conscientious washing may be ineffective. These articles should therefore be boiled.

(8) Tubes and ampoules

Tubes of catgut and ampoules of anaesthetic solutions or other drugs, the contents of which are sterile, are often provided for use immersed in a disinfectant solution so that their outer surface may also be sterile. Spirit has limitations for this, as for other purposes, and more potent disinfectants are undesirable, since they may contaminate the contents. Unorthodox as this suggestion may be, it seems that this need can be met in an entirely different way. Immersion for 24 hours in a formalin solution will completely sterilize the surface of such tubes: this can be carried out at leisure when they are first supplied. They can then be kept until required in any air-tight container, whence they are removed with sterile forceps. It is not sufficiently understood that a sterile object will remain sterile indefinitely if merely protected from atmospheric dust, as by wrapping in paper, Cellophane or several layers of fabric, or placing in any box with a reasonably tight-fitting lid.

Limitations of spirit

Formalin solution

Period of sterility

(9) Baths

Arm-baths and other vessels in which limbs (or the entire body) are immerse[d] for the treatment of septic conditions can be a prolific vehicle of cros[s]

infection (Medical Research Council, 1941). They are particularly difficult to disinfect if Vaseline gauze dressings have been used, since the grease adheres to the walls. Heat should be used to disinfect them if possible: if not, the disinfectants which have been said to be capable of doing so are strong Lysol or Cetavlon.

6. CLEANING

Everything that has been said hitherto except in the immediately foregoing section presupposes that the article to be sterilized has first been cleaned. It is one thing to destroy a few "naked" bacteria on a glass or metal surface, and quite another to attack them if they are embedded in a film of pus or blood. It is one of the advantages of heat that it operates regardless of this factor, whereas disinfectants, particularly spirit or anything dissolved in it, penetrates such films slowly if at all. The cleaning of some kinds of surgical apparatus is a troublesome and time-consuming business, but it must be thorough if subsequent disinfection by chemical means is to have a chance.

Advantages of heat

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STOMACH—DISEASES OF

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1. GASTRITIS

312.] Inflammatory and degenerative lesions of the stomach which may be designated gastritis are usually only of indirect interest to the surgeon, as exemplified by the association of atrophic gastritis with simple and malignant gastric tumours. Three types of gastritis are of more direct interest—acute erosive, corrosive and acute phlegmonous gastritis.

(1) Acute erosive gastritis

Acute erosive gastritis is important to the surgeon since it may present as gastric haemorrhage with a history of chronic dyspepsia, requiring surgical aid to stop the bleeding. The condition can only be recognized gastroscopically, or by gastrotomy at operation, when mucosal erosions may be seen associated with either a hypertrophic or an atrophic mucosa.

(2) *Corrosive gastritis*

This term is applied to the severe inflammatory and ulcerative lesions which may affect the stomach after the swallowing of corrosives. The gastric symptoms are usually overshadowed by the symptoms produced in the mouth, pharynx and oesophagus. Occasionally, however, the fibrosis accompanying healing of a gastric lesion may produce pyloric obstruction and require surgical aid. More rarely the patient may present as an "acute abdomen", though the general symptoms due to absorption of the corrosive poison, the burning of the mouth and lips, and the history will help to differentiate it from other acute abdominal catastrophes. *Pyloric obstruction*

(3) Acute phlegmonous gastritis

(a) *Definition*

This is a very rare suppurative form of gastritis.

(b) *Aetiology*

It may occur in patients with suppurative lesions in other parts of the body. It may be associated with ulcerative gastric lesions. Its causation is unknown but the streptococcus has in some cases been recognized as the causative organism.

(c) *Pathology*

There is submucosal purulent inflammation of part or all of the stomach. Single or multiple abscesses may form, and may burst through either the mucosal (Fink, 1937) or the peritoneal surface. *Formation of abscesses*

(d) *Clinical picture*

The disease is heralded by severe epigastric pain and vomiting of sudden onset. The temperature rises and the abdomen is rigid and extremely tender in the epigastrium A pre-operative diagnosis of perforated ulcer or of acute cholecystitis is usually made. The condition is first diagnosed at laparotomy or necropsy.

(e) *Prognosis*

The mortality of the condition has hitherto been extremely high: probably the mortality will diminish with modern chemotherapy.

(f) Operative technique

In the past, recovery has followed drainage of a local abscess, or gastric resection. No doubt the correct treatment nowadays is to drain any abscess present (non-operative treatment is not considered because the condition is so rarely recognized before operation). It may, at times, be possible to open the stomach at a less involved area and drain the abscess into its lumen. Following operation, the sulphonamides and penicillin are given in full doses.

Post-operative chemotherapy

2. INJURIES OF THE STOMACH

(1) Definition

The stomach may be injured by crushing injuries of the abdomen or lower thorax, by penetrating wounds, and by perforation with endoscopes or swallowed foreign bodies, or it may rupture spontaneously.

(2) Aetiology

The mobility of the stomach renders it less liable to injury, though a full stomach is prone to burst on crushing. In a series of penetrating wounds treated during World War II the stomach was involved in about 10 per cent of the abdominal and 25 per cent of the thoraco-abdominal wounds (Porritt, 1946).

Injury caused by gastroscopic examination

Injury to the stomach, in the course of gastroscopic examination, by perforation of an ulcer or a carcinoma or even an intact wall may occur with the rigid gastroscope, but no such injury has been reported to have occurred during the use of a flexible gastroscope.

Spontaneous rupture of the stomach is an extremely rare event but it has occurred when a large meal has been taken after a period of prolonged starvation.

(3) Clinical picture

If the stomach is empty at the time of injury, leakage may be slight and the symptoms may also be slight. If the stomach is full, pain is severe with general abdominal rigidity and tenderness and early development of peritonitis. In thoraco-abdominal injuries the gastric contents may enter the thorax or even escape from the wound.

(4) Aids to diagnosis

Radiological examination

A skiagram may show free gas under the diaphragm, or gas and fluid in the left pleural cavity.

(5) Differential diagnosis

It is unimportant to diagnose pre-operatively precisely which viscus is injured. Contusion of the abdominal wall or fracture of the lower ribs is likely to mimic intraperitoneal visceral injury. The latter will be associated with steadily increasing rigidity; there will be absence of peristaltic sounds, and free gas in the peritoneal cavity later.

(6) Prognosis

The mortality of stomach injuries depends upon the nature and extent of associated injuries (Wallace, 1917).

In uncomplicated abdominal injuries of war involving the stomach Porritt records a mortality of 21 per cent. In thoraco-abdominal wounds injury to

the stomach alone gave a mortality of 43 per cent, but if other viscera were also damaged the mortality rose to 68 per cent (Porritt, 1946)

(7) Operative technique

Time is given for the administration of morphine and replacement of lost blood.

If there is a thoraco-abdominal wound, it will often be convenient to explore the stomach through the diaphragm after the chest wound has been widely opened. If the chest is intact an upper abdominal approach is used.

The stomach is carefully explored both on its anterior and its posterior surfaces. Almost any wound of the stomach may be treated by suture without fear of impoverishing the blood supply. If part of the stomach wall is almost separated, this part of the organ may be removed. If gastric vessels are damaged and require ligation no concern need be felt about the viability of the stomach.

After dealing with any associated injuries, any excess of food debris or exudate is mopped out or aspirated from the peritoneal cavity and the wound *Aspiration*
closed without drainage unless peritonitis has already supervened. *and closure*

3. FOREIGN BODIES IN THE STOMACH

(1) Aetiology

Foreign bodies may be accidentally swallowed, for example, pins and nails by dressmakers or cobblers or Kirby grips by children Bizarre objects may be swallowed by prison inmates, hysterical or insane persons or for a wager.

Bezoars, or aggregations of swallowed material, may form large masses in the stomach and may even form a cast of it. The commonest constituents of the bezoar are hair, vegetable fibres, wool or cotton.

(2) Pathology

Slow or acute perforation of the stomach may be caused by the sharper or irregular objects. Gastric ulcer is sometimes found in association with the *Associated*
bezoar, and possibly the bezoar is the cause of it. In the presence of pyloric *gastric ulcer*
stenosis, objects which would normally pass may be retained in the stomach.

(3) Clinical picture

In the majority of cases a history of swallowing the foreign body is given. There may be a history of "hair-sucking". Once a foreign body has reached the stomach symptoms are usually absent, though epigastric discomfort and vomiting may occur if there is a large collection of foreign bodies. A large hair ball may produce obstructive symptoms. If gastric perforation takes place signs of a local or general peritonitis will appear.

Some of the large bezoars may become palpable abdominally.

(4) Special aids to diagnosis

As most of the foreign bodies are opaque to x-rays a plain skiagram will often disclose them. Barium-meal examination will confirm that the foreign *Barium-meal*
body is in the stomach, and a bezoar will show as a rounded filling defect in
the dependent part of the stomach. Gastroscopy is usually unnecessary, but may confirm the presence of the swallowed object.

(5) Differential diagnosis

The bezoar may be distinguished from rounded gastric tumours by its mobility, lack of pedicle or of distortion of the gastric outline on radiological examination, and by gastroscopic visualization.

(6) Indications for surgical intervention

Nearly all foreign bodies which will pass through the oesophagus will negotiate the remainder of the alimentary tract without harm, though it may be necessary to wait a few weeks until the object leaves the stomach.

Surgical removal is indicated for those objects such as bezoars which have increased in size, for long objects such as long knives or spoons which will probably not negotiate the curve of the duodenum, for dangerous objects such as hooks and bent wire, or for heavy accumulations of foreign bodies.

If in doubt a trial of waiting should be given, for a surprising number of foreign bodies will pass. An expectant policy is particularly advisable in those who repeatedly swallow foreign bodies.

Gastric perforation

Signs of gastric perforation are an indication for immediate surgery.

(7) Operative treatment

It is important to have a skiagram confirming the presence of the foreign body immediately before operation.

It is possible to remove certain foreign bodies by the use of a rigid gastroscope, but the method is not much favoured because it is more risky than gastrotomy in the hands of most surgeons (Jackson and Jackson, 1936).

Incision

Under suitable anaesthesia the stomach is exposed by an upper abdominal incision. The foreign body or bodies are withdrawn through as small a gastrotomy opening as possible, after carefully packing off the peritoneal cavity, and aspirating the gastric juice. The stomach wall is closed with two layers of fine chromic catgut and the abdomen closed in the usual way without drainage.

4. SIMPLE TUMOURS OF THE STOMACH

(1) Definition

Benign tumours may arise from any of the layers of stomach wall and may project into the lumen of the stomach or into the peritoneal cavity or both.

(2) Aetiology

Simple tumours of the stomach occur at all ages but are commoner in the later years of life. There is no difference in incidence in the sexes. The incidence is difficult to determine accurately. The author found 15 simple tumours in 1,730 consecutive patients on gastroscopic examination (Tanner, 1944). Necropsy figures show an incidence of benign gastric tumours of between 0 3 per cent and 0 8 per cent, and Spriggs and Marxer found an incidence of 0·3 per cent in all stomachs examined radiologically (Spriggs and Marxer, 1943). There is evidence that simple tumours [illegible] common in stomachs which are the seat of atrophic gastritis, [illegible] with pernicious anaemia.

Associated diseases

(3) Pathology

The tumours [illegible] into those of [illegible] and adenoma—and [illegible] ive tissue [illegible] the

Ulceration Ulceration of the tumour may give rise to the commonest presenting symptoms—haematemesis and melaena. Sometimes persistent slight bleeding causes chronic anaemia.

The exogastric tumours may remain symptomless until they reach such a size as to produce an abdominal mass or undergo torsion or degeneration.

Sometimes the tumour is only brought to light during the investigation of dyspepsia caused by an associated atrophic gastritis, of pernicious anaemia, of an associated malignant gastric tumour or of some other gastric lesion

(5) Special aids to diagnosis

The blood picture often reveals an anaemia of the hypochromic iron deficiency type; rarely, there is a picture of primary pernicious anaemia.

Occult or obvious blood may be found in the stools.

Fractional test meal examination will disclose an achlorhydria in a high percentage of the cases of multiple polyposis, and blood may be present in the aspirated gastric contents.



Fig. 14—X-ray of leiomyoma of stomach showing smooth rounded filling defect and unaltered gastric contour.

Radiological examination Radiological examination may show one or more smooth rounded filling defects, though if too much barium is given the smaller tumours may be missed. As the tumours are not invasive, the stomach outline is regular and peristalsis is unaltered in the region of origin of the tumour (Fig. 14). A pedicle to a polypoid tumour may be recognized. The tumour is mobile and occasionally may be seen to enter the duodenum. A niche may be seen in the

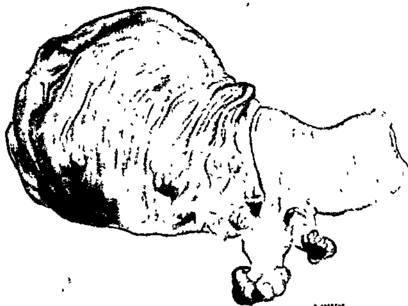
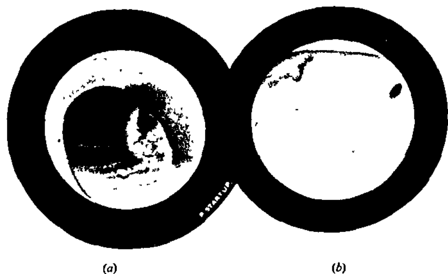


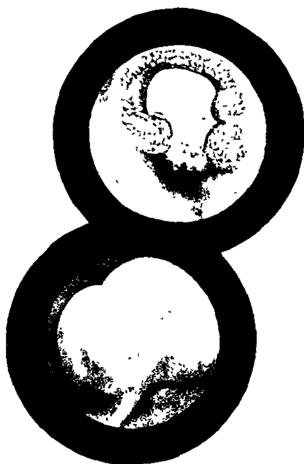
FIG 1.—Multiple polypoid adenomas of the stomach. (The resected stomach is turned inside out to demonstrate them.)



(a) (b)

FIG. 2.—(a) Gastroscopic view of ulcerating carcinoma with round nodular edge in the pyloric antrum. (b) Gastroscopic view of gastric diverticulum. There is also a small mucosal tumour present.

PLATE I



P. Startup

Gastroscopic appearance of an ulcerating leiomyoma.
(*Proc. R. Soc. Med.*)

PLATE II

translucent tumour area, indicating that ulceration has occurred (Buckstein, 1948a).

Gastroscopic examination is commonly the only means by which the smaller *Gas* tumours are recognized, and it is also the best clinical method by which the *exa* benign and malignant neoplasms can be differentiated. In a high percentage of the cases of epithelial tumours, and rather less frequently in the connective-tissue tumours, there will be evidence of atrophic gastritis. The tumours are readily observed; those of epithelial origin appear as small localized nipple-like or polypoid elevations slightly redder than the surrounding mucosa, and they may be multiple. Ulceration is rarely present unless malignant degeneration has occurred. The connective-tissue tumours tend to be larger in size, and they are seen as submucosal masses which have lifted up and stretched the normal mucosa, so that the rugae pass from healthy stomach to the periphery of the tumour. This crossing of the valley around the tumour has been called by Schindler, Sandweiss and Mintz (1942) the "bridging *"Bri* folds sign" and indicates the submucosal position of the tumour. Ulcera- *fold* tion may be deep and multiple and it is difficult to be certain of the benign nature of such tumours (Plate II).

Peritoneoscopy has a small field of usefulness; it may show that an abdominal mass is attached to the stomach, or that the tumour has become malignant, if peritoneal metastases are seen.

(6) Differential diagnosis

Hypertrophic folds are sometimes radiologically similar to small simple tumours, but gastroscopic examination of the well-inflated stomach differentiates the conditions.

Bezoars resemble the larger tumours but they have no pedicle, may be radiologically opaque and a history, for example of hair-sucking, may be given. Gastroscopy will differentiate the conditions. The characteristic features of malignant tumours will be described in the next section.

(7) Prognosis

The main risk so far as the epithelial tumour is concerned is that of carcinomatous degeneration. Pearl and Brunn (1943) found malignant transformation in 19 out of 37 cases of apparently benign multiple polyposis.

There is some risk to life from haemorrhage in the benign tumours, particu- *Haem* larly the ulcerating leiomyomas but malignant transformation is much less common and less dangerous.

(8) Indications for surgical treatment

In cases of multiple polyposis, gastric resection is advisable because of the tendency to develop malignant characters. If the whole stomach is involved the resection may have to include all but a small cuff of gastric tissue at the cardia.

Large connective-tissue tumours should also be removed because of the risk of bleeding but, since a local excision is adequate, in most cases the operation is not one of great severity.

Symptoms of pyloric obstruction or suspicion of malignancy are always indications for surgical extirpation of the tumour.

Small solitary polypi should be kept under radiological or gastroscopic

(9) Pre-operative management of the patient

Anaemia should be treated by means of iron therapy or blood transfusion. Nutritional deficiencies may require correction.

(10) Operative technique

Surgical approach

For a tumour or tumours near the cardia, particularly if the patient is deep-chested or also has a hiatal hernia, an abdomino-thoracic approach may be used (*see* the section on Carcinoma of the Stomach, p 72). In the majority of cases, however, an upper abdominal approach to the stomach is adequate.

Gastrotomy

On inspection and palpation of the stomach the tumour is usually evident, but epithelial tumours are sometimes difficult to feel, or may feel like thickened folds Thus it is well to have an accurate knowledge of the number and position of the tumours before operation. In rare cases it may be necessary to pack off the stomach, open it, aspirate the contents and inspect the interior with the aid of broad retractors and a head-lamp—not a desirable procedure as a routine.

Epithelial tumours

As the pyloric part of the stomach is the part most commonly involved by the epithelial tumours a partial gastric resection removing the antrum and a variable part of the body of the stomach is required.

Connective-tissue tumours

In the case of the bulkier connective-tissue tumours, the tumour and a small margin of healthy stomach is removed. There is often some nodularity at the base of the leiomyomas and this may be of no significance, but any induration round the base should be regarded as a sign of malignancy and a much wider margin of gastric tissue should be removed. The wound left after resection of the mass is resutured at right angles to the long axis of the stomach. Tumours of the posterior wall of the stomach may be approached by mobilizing the greater and lesser curvatures and rotating the stomach. Polypoid tumours high on the posterior wall are sometimes most easily dealt with by transgastric excision—that is, through an incision in the anterior surface of the body of the stomach

If the antrum is widely involved by a mesoblastic tumour it may be easier to perform an orthodox partial gastrectomy, and if the middle of a long hypotonic stomach is affected a sleeve resection is sometimes neater and involves less peritoneal soiling.

Subperitoneal tumours can usually be dealt with by ligation of the pedicle and excision.

(11) Results of treatment

These operations are associated with a low mortality. There is no tendency to recurrence in the simple connective-tissue tumours, and even if histological examination subsequently reveals malignant change the prognosis is good, though in such cases there is occasionally a recurrence.

5. CARCINOMA OF THE STOMACH

(1) Definition

Carcinoma is the commonest epithelial tumour of the stomach.

(2) Aetiology

Cancer of the stomach is one of the commonest malignant tumours and in England it accounts for about one-quarter of the total cancer deaths. The

disease is found to be approximately equally prevalent among all races if there are adequate facilities for diagnosis and if the expectation of life is sufficiently long for an equally high proportion of the population to reach the cancer age (Pack and McNeer, 1948)

Age and sex incidence

The disease is commonest in the sixth decade, and affects men more frequently than women in a proportion of two to one. It is commoner in the lower social classes (Registrar-General's Reports for England and Wales, 1930–32)

Gastric ulcer appears to be the precursor of gastric carcinoma in a small percentage of cases—about 6 per cent according to Dible (1925). Gastritis, particularly the atrophic form, is possibly a precancerous lesion but incontrovertible evidence of this has not yet been given The tendency of simple epithelial tumours of the stomach to become malignant has been mentioned. (*See* Simple Tumours of the Stomach, p. 57.)

The part played by oral infection, dietetic habits and ingestion of carcinogens has not been elucidated and in the majority of cases the causative agent is quite unknown.

(3) Surgical anatomy

To gain a knowledge of the lymphatic supply of the stomach the surgeon treating malignant disease of the stomach is recommended to study the classic description by Jamieson and Dobson (1907)

It is disconcerting to realize that some of the lymphatic vessels from the stomach drain into glands which are quite unconnected with the stomach.

The lymphatic vessels of the stomach intercommunicate freely, and there is free communication with the vessels of the oesophagus, but communication with those of the duodenum, although it has been occasionally demonstrated, is less obvious.

Primary lymphatic drainage

The vessels from the lesser curvature of the stomach pass towards the glands grouped round the descending branch of the left gastric artery and to those round its main stem. From the region of the cardia vessels pass to the paracardial glands which surround the cardia "like a chain of beads", and even some pyloric vessels may pass to this group. The vessels from the upper part of the greater curve of the stomach pass to the glands in the gastro-splenic omentum, in the splenic hilum and adjacent to the pancreatic tail (the "splenic" group). Glands from the right half of the greater curve and some from the pyloric region pass to the glands round the right gastro-epiploic vessels and to the subpyloric glands. A few vessels from above the pylorus may enter a suprapyloric gland or the biliary chain of glands (Figs. 15 and 16).

From these glands the further drainage is briefly as follows

Secondary groups of glands

The glands round the stem of the left gastric artery and also the paracardial glands continue into those round the coeliac artery—the middle suprapancreatic group. The splenic group of glands drain into the glands round the splenic artery (the left suprapancreatic glands) and thence to the coeliac group. The right gastro-epiploic glands drain into the subpyloric glands, and from the latter many vessels pass direct to the superior mesenteric glands; this explains the frequency with which these glands are involved in carcinoma of the pyloric end of the stomach. Others pass upwards to the coeliac group

of glands. Occasionally vessels course from the suprapyloric glands to the glands round the main stem of the hepatic artery as it lies above the pancreas—the right suprapancreatic group of glands.

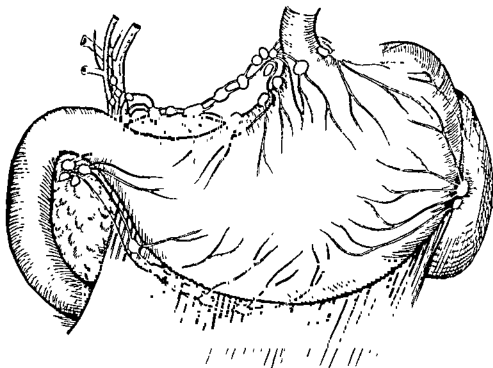


FIG 15—The lymphatics of the stomach. (*After Jamieson and Dobson.*)

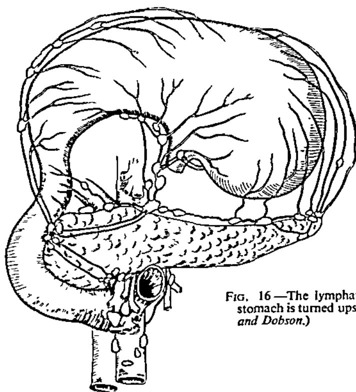


FIG. 16—The lymphatics of the stomach. The stomach is turned upside down. (*After Jamieson and Dobson.*)

Two vascular abnormalities must also be borne in mind in the treatment of gastric carcinoma. Occasionally a large artery is seen passing from the left gastric artery between the layers of the gastro-hepatic ligament to enter the liver. This vessel may be an accessory left hepatic artery, or it may be the only blood supply to the left lobe of the liver. *Vascular anomalies*

The second vascular abnormality which, as it is common, might in fact be called a normal finding, is that one or more branches may pass from the middle of the splenic artery up behind the lesser sac and then arch forward to enter the highest part of the greater curve of the stomach; they are accessory vasa brevia.

(4) Pathology

Carcinoma may arise in any part of the stomach, the relative frequencies being as follows (Willis, 1948).

Pylorus and antrum - -	47 per cent
Lesser curvature - -	26 per cent
Cardia region - - -	10 per cent
Rest of organ - - -	9 per cent
Whole stomach - - -	8 per cent

Site of gastric carcinoma

The tumour is usually single, but rarely double growths with intervening healthy stomach are seen. Macroscopically the tumours vary from a cauliflower-like tumour, to an ulcerative lesion with an everted or infiltrative edge, or to a diffuse infiltrative thickening with only the slightest ulceration. Borrmann's classification is practical. He divides gastric cancer into four types, the percentages of incidence in which are those given by Schindler (1946).

Type 1.—In this classification Type 1 is the sharply limited polypoidal tumour which projects hemispherically into the lumen of the stomach. It often looks like a mushroom with overhanging edges, its surface presenting numerous nodules which usually are of different sizes. Ulceration of the surface develops late. The mucosa surrounding this type of tumour is often thoroughly atrophic. Its incidence is about 2·9 per cent of all gastric carcinomas (Fig. 17). *Borrmann's macroscopic classification*

Type 2.—This is also a sharply limited tumour. It consists of an ulcer surrounded by an elevated wall. This wall has a steep slope towards the surrounding mucosa and is sharply demarcated all around. The floor sometimes shows necrotic material of various colours. The wall may be smooth, or more frequently it is nodular and contains shallow erosions. Its dark red colour then is in marked contrast to the pale colour of the surrounding mucosa (Fig. 18). Its incidence is 17·6 per cent.

Type 3.—This is easily confused with Type 2. It also consists of an ulceration and of a wall. But the wall does not surround the whole circumference of the ulcer. The ulcer, sharply limited on one side, blends diffusely at some point with the neighbouring mucosa which is diffusely infiltrated. Therefore this is not a sharply limited but an infiltrative type of carcinoma (Fig. 19). Its incidence is 16·3 per cent.

Type 4.—This type comprises the diffusely infiltrative tumours. No sharp limit is found anywhere; sometimes the entire stomach may be infiltrated. Within this infiltration, ulceration may develop with shallow or deep ulcers. The incidence of this type is 63 2 per cent (Fig 20)



FIG. 17.—Borrmann I type of gastric carcinoma



FIG. 18.—Borrmann II type of gastric carcinoma

Microscopical examination shows all variants of glandular carcinoma, from a type showing distinct differentiation of acinar structures to a highly cellular anaplastic carcinoma. Much extra-cellular mucoid material may be produced



FIG 19.—Borrmann III type of gastric carcinoma

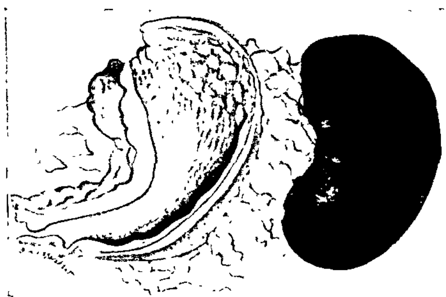


FIG. 20.—Borrmann IV type of gastric carcinoma.

by the acini, or spheroidal cells with or without intracellular mucus may be present. These varying forms of microscopic structure are not only seen in different growths, but may be seen in different parts of the same growth, making it difficult to predict the degree of malignancy from its microscopic structure alone.

Gastric carcinoma may spread directly into the oesophagus and less frequently into the duodenum. It may invade the peritoneal coat and then the neighbouring structures, pancreas, liver, colon, spleen, omenta, or abdominal wall. Metastases may pass to the regional lymph glands and to the thoracic duct, from which emboli may cause pulmonary secondary growths. Wide spread lymphatic permeation may occur and the supraclavicular, axillary or inguinal lymph glands may be affected.

Distant metastases

Malignant emboli may pass through the portal vein to the liver. Diffuse peritoneal metastases may occur and bilateral myxomatous tumours of the ovaries—Krukenberg tumours—may arise in the female. The latter tumours are characterized by the spheroidal mucus-secreting cell, the "signet-ring cell".

Umbilical ulceration may occur from spread of growth along the ligamentum teres. Any organ in the body may be affected by blood-borne metastases.

(5) Clinical picture

The presence of a carcinoma in the stomach appears to cause remarkably few symptoms unless the growth bleeds or, being near the cardiac or pyloric orifice, causes obstructive symptoms. Consequently most patients disregard the early symptoms for about 6 months before consulting a physician. It is important to regard these early symptoms seriously when they are complained of by patients of the cancer age. Any disturbance of the digestive function commencing in a patient aged 45 years or over must be regarded as probable cancer of the stomach until malignancy is disproved.

Early symptoms

The earliest symptom may be merely a vague feeling of ill health, or loss of energy or of weight. Alteration or diminution of appetite for food or drink or even for smoking may be complained of. Persistent nausea is sometimes present.

Vague epigastric discomfort, "fullness", colic, hiccup or belching may be the first complaint. A dyspepsia similar to that of peptic ulcer is not uncommon, and food or an alkali may give relief.

At times the early symptoms may be unassociated with the stomach, being, for example, constipation or even diarrhoea.

Haemorrhage

If haemorrhage occurs it may be insidious, the patient complaining of lethargy, pallor, giddiness or breathlessness, or it may be severe and present as a massive haematemesis or melaena.

Obstruction

Pyloric obstruction may give rise to epigastric discomfort, anorexia and vomiting. Obstruction of the cardiac orifice will give rise to symptoms resembling those of oesophageal obstruction.

Tumour

Less commonly the patient may consult the doctor because he has felt a mass in the abdomen or he may complain of symptoms which are due to distant metastases.

Chronic dyspepsia and gastric cancer

The diagnosis of carcinoma is often delayed in patients who suffer from long-standing dyspepsia, and an alteration of the symptoms or the addition of such complaints as anorexia, loss of weight and pallor should give rise to suspicion. These cases are not necessarily of carcinoma developing in simple ulcers, for in many the preceding dyspepsia may have been due to gastritis or have been of biliary or functional origin.

occurs and may produce gastric or pyloric obstruction. The whole stomach may be involved so that it becomes like a rigid tube through which the meal rapidly passes into the duodenum (Fig. 21), and oesophageal dilatation usually occurs.



FIG. 21.—Diffuse infiltrating carcinoma. Most of stomach is converted to a narrow rather irregular tube.

Other radiological findings are deformity of the gastric air-bubble, soft-tissue opacity due to tumour, and splitting of the barium stream through the stomach.

(b) Gastroscopic examination

Visualization of the tumour itself with the flexible gastroscope makes the diagnosis certain in a high proportion of cases or, perhaps equally important, it may serve to exclude the diagnosis of carcinoma.

Introduction of the gastroscope

The first feature noted by the gastroscopist is the tendency of the growth to obstruct the passage of the instrument, and this may occur at the cardia. Needless to say, force must not be used in such cases for fear of perforating the tumour, and if gentle manipulation fails to secure progress the examination must be abandoned. Another feature specially noticeable in the growths is the difficulty experienced in distending the stomach with air, which escapes into duodenum and oesophagus as fast as it is introduced.

On inspecting the growth the first impression is that the lesion is completely irregular in shape and colour, with great stillness due to absence of peristaltic movements.

Polypoid lesions

Polypoid lesions with their irregular nodules and ulcers, bleeding areas, patches of slime and opaque mucus, and adjacent induration are usually obviously carcinomatous.

Ulcerative lesions

The ulcerative lesions of the Borrmann Types 2 and 3 show an everted or indurated edge, with central ulceration irregular in form and colouring (Plate I, Fig. 2 (a)). The wavy line of new epithelium seen round a simple ulcer is absent. Radiating folds may be seen; these are due not to contraction

of the ulcer area as in simple ulcer, but to the fact that the surrounding folds are " frozen " close together by infiltration with growth, whereas the more distant folds widen when the stomach is distended.

Diffuse infiltrative carcinoma

The purely infiltrative type of carcinoma is the most difficult to diagnose, both because of the slight mucosal alteration and because of the difficulty in distending the stomach enough to inspect it. The folds appear congested, irregular and thickened. Superficial pale ulcers may be seen. Peristaltic movements are absent in the involved part.

(c) *Other diagnostic methods*

Fractional test meal

The fractional test meal may occasionally be helpful. In about 75 per cent of the cases of gastric carcinoma hypochlorhydria or achlorhydria is present when the diagnosis is made. The presence of blood in the stomach in addition to a low free acidity increases the likelihood of carcinoma, particularly if the total acidity is high.

If dental, oral and rectal bleeding can be excluded then the persistent presence of occult blood in the faeces points most commonly to gastric or colonic carcinoma.

Peritoneoscopy is usually unnecessary, but in cases of doubtful operability it may disclose the presence of hepatic or peritoneal metastases, and the primary gastric tumour may be seen.

(8) Differential diagnosis

The differential diagnosis between simple peptic ulcer and carcinoma has been considered.

Filling defects may be produced by food debris, bezoars, or thickened folds of mucosa. Repeat skiagrams after emptying the stomach, or gastroscopy, serve to differentiate them.

Carcinoma is sometimes confused with pernicious anaemia. The presence of blood in the fractional test meal is an indication of the former, particularly if the total acidity is high. Radiological and gastroscopic examination may show or exclude carcinoma. At times carcinoma develops in sufferers from pernicious anaemia.

Linitis plastica

Benign gastric tumours lack the infiltrative and irregular features of carcinoma. *Linitis plastica* is described as a benign infiltrative lesion at times, and attempts are made to differentiate it from the malignant form. It is probable that all such cases are examples of scirrhous carcinoma, though extensive search may be required in order to find malignant cells (Saphir and Parker, 1943).

Leukaemic and lymphadenomatous infiltration of the stomach may be diagnosed by occasional duodenal involvement as seen radiologically, by the blood picture or by glandular biopsy, but occasionally laparotomy is required for an accurate diagnosis.

(9) Prognosis

A survey of 1,405 cases of gastric carcinoma treated in London between 1938 and 1939 revealed that 56 of the patients were still alive at the end of 5 years, 36 having been treated by partial gastrectomy, and 10 probably having been incorrectly diagnosed. Estimation of survival by actuarial methods showed that if gastric resection was performed before lymph gland

Survival rate

involvement occurred there was 60–63 per cent of normal expectation of life over a 5-year period. After the lymph glands were involved, gastrectomy gave only 40–43 per cent of normal life expectation (Harnett, 1947).

No doubt the prognosis for the sufferer from gastric cancer has improved since 1939, not only as a result of improvement in the methods of diagnosis but also because resection mortalities are lower, and removal of the higher gastric growths has become possible with a reasonable mortality.

(10) Indications for surgical intervention

In view of the hopeless prognosis of untreated gastric cancer it is advisable to treat surgically all operable cases in which there is otherwise a reasonable expectation of life, such complications as coronary, renal, prostatic and pulmonary disease being considered in deciding the life expectation. Advanced age in itself is no absolute contra-indication so long as the patient can enjoy life and is not bedridden.

Evidence of distant metastases usually contra-indicates surgical treatment though even in such cases it is sometimes justifiable to perform palliative short-circuiting operations for pyloric or lower gastric obstruction.

Complications of gastric carcinoma

Occasionally complications of the growth make urgent surgery imperative. Perforation through the tumour may be treated by immediate gastric resection in good-risk cases, or by closure of the perforation in others. Massive haemorrhage from a carcinoma is often persistent and in such cases the best means of arresting the haemorrhage is by gastric resection when this is possible.

Perigastric abscess in association with carcinoma is treated by drainage of the abscess. This may be followed by a gastric fistula which will require re-operation and gastric resection, or transection above the fistula.

(11) Pre-operative management of the patient

Particularly when anorexia or dyspepsia has been a prominent symptom, the patient's state of nutrition may have deteriorated and will require correction by a combination of rest and easily digested soft foods. As protein is important for wound healing, milk and eggs will form the mainstay of the diet, though other foods of high caloric value should be given, otherwise the protein will be broken down and utilized as carbohydrate. Aged, alcoholic or starved patients are prone to develop acute vitamin B deficiencies after operation, so full doses of nicotinamide, riboflavine, and thiamine are added. Vitamin C is given because of its function in the formation of fibrous tissue.

If gastric obstruction is severe, repeated gastric lavage with saline solution will diminish the obstruction. In high gastric or low oesophageal obstruction it may be necessary to remove food debris from the oesophagus through an oesophagoscope.

In severe cases intravenous feeding will be given and, rarely, a feeding jejunostomy is required.

Anaemia

Some degree of anaemia is usually present and is treated by the administration of ferrous sulphate, but a high proportion will also require repeated blood transfusion. It is desirable to obtain a haemoglobin value of 70 per cent before operation.

Oral, nasal and dental infections are dealt with so far as is possible without drastic measures. In dental infections treatment is by attention to the gums,

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Breathing, leg and general exercises are given to prevent pulmonary or venous stagnation.

For 6 hours before operation penicillin lozenges are given as an oral antiseptic. Prophylactic chemotherapy diminishes the possibility of pulmonary or abdominal infection and should be started before operation, so that a bacteriostatic blood concentration is obtained by the time the operation is commenced. There is much to be said for using one of the sulphonamide drugs and keeping penicillin as a second line of defence. *Prophylactic chemotherapy*

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Tumours of the middle and lower stomach will be considered first. These are approached by a high abdominal incision. A careful inspection of the growth and its extensions is made. Spread to distant peritoneum or pelvis, metastases in the liver or distant glands render the case incurable, though a palliative short-circuiting operation is performed if there are severe obstructive symptoms. *Carcinoma of the pyloric end of the stomach*

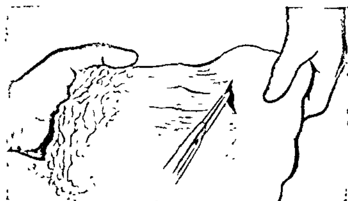


FIG. 22.—Commencement of separation of the gastro-colic omentum from colon.

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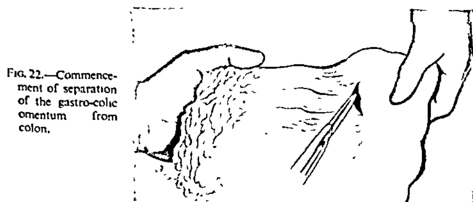


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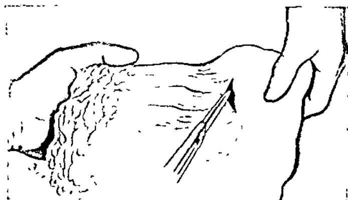


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Separation of gastro-colic omentum.

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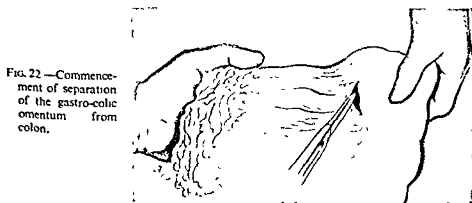
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Perigastric abscess in association with carcinoma is treated by drainage of the abscess. This may be followed by a gastric fistula which will require re-operation and gastric resection, or transection above the fistula.

(11) Pre-operative management of the patient

Particularly when anorexia or dyspepsia has been a prominent symptom, the patient's state of nutrition may have deteriorated and will require correction by a combination of rest and easily digested soft foods. As protein is important for wound healing, milk and eggs will form the mainstay of the diet, though other foods of high caloric value should be given, otherwise the protein will be broken down and utilized as carbohydrate. Aged, alcoholic or starved patients are prone to develop acute vitamin B deficiencies after operation, so full doses of nicotinamide, riboflavine, and thiamine are added. Vitamin C is given because of its function in the formation of fibrous tissue.

If gastric obstruction is severe, repeated gastric lavage with saline solution will diminish the obstruction. In high gastric or low oesophageal obstruction it may be necessary to remove food debris from the oesophagus through an oesophagoscope.

In severe cases intravenous feeding will be given and, rarely, a feeding jejunostomy is required.

Anaemia

Some degree of anaemia is usually present and is treated by the administration of ferrous sulphate, but a high proportion will also require repeated blood transfusion. It is desirable to obtain a haemoglobin value of 70 per cent before operation.

Oral, nasal and dental infections are dealt with so far as is possible without drastic measures. In dental infections treatment is by attention to the gums,

scaling of teeth and dental cleansing rather than by extractions unless the teeth are few or very loose.

Breathing, leg and general exercises are given to prevent pulmonary or venous stagnation.

Prophylactic chemotherapy

For 6 hours before operation penicillin lozenges are given as an oral antiseptic. Prophylactic chemotherapy diminishes the possibility of pulmonary or abdominal infection and should be started before operation, so that a bacteriostatic blood concentration is obtained by the time the operation is commenced. There is much to be said for using one of the sulphonamide drugs and keeping penicillin as a second line of defence.

It is well to give a gastric lavage 2 or 3 hours before operation, particularly if the patient has gastric obstruction or hypochlorhydria. It is useful to leave a soft oesophageal tube in the stomach during the operation.

(12) Operative technique

The only curative operation for gastric carcinoma is resection, and to obtain the greatest safeguard against recurrence a wide resection should be made ablating not only part or all of the stomach but also the adjacent tissues. Therefore a wide resection of the stomach is made with a length of duodenum, and at times some oesophagus, and also the adjacent lymph glands and omenta. The operation is varied to suit the position and extent of the growth, and at times the spleen or parts of the colon, mesocolon, liver or pancreas may also require removal

(*a*) *Resection of the middle and lower stomach*

Carcinoma of the pyloric end of the stomach

Tumours of the middle and lower stomach will be considered first. These are approached by a high abdominal incision. A careful inspection of the growth and its extensions is made. Spread to distant peritoneum or pelvis, metastases in the liver or distant glands render the case incurable, though a palliative short-circuiting operation is performed if there are severe obstructive symptoms.

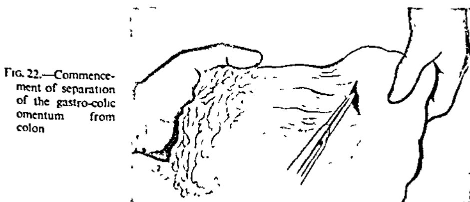


FIG. 22.—Commencement of separation of the gastro-colic omentum from colon

Separation

When it is decided that the growth is resectable, by lifting up the great omentum and with the assistant holding the colon firmly, the avascular line between the [illegible]

upward o [illegible]

There are no large vessels to divide because the colon and omentum are bound together merely by embryological adhesions. The separation is continued to the right as far as the duodenum, and to well above the tumour on the left. The subpyloric glands lying in the region of the bifurcation of the gastro-duodenal artery are recognized and separated from the pancreas. The gastro-duodenal artery and vein are ligated and divided, then the glands are freed, remaining attached to the stomach.

Separation of gastro-hepatic omentum

The right gastric artery and vein are found and tied near their origin and peripheral to the *suprapyloric gland if this is present. The gastro-hepatic* omentum is divided upwards to the porta hepatis and then, with scissors, it *is separated from its attachment* to the liver until it is *attached only to the lesser* curve of the stomach (Fig. 23) *A small vessel usually* requires division but the *possibility of an abnormal* hepatic artery should be *kept in mind if a larger* vessel is seen, for it may *need to be preserved. (See* Surgical Anatomy, p. 61.)

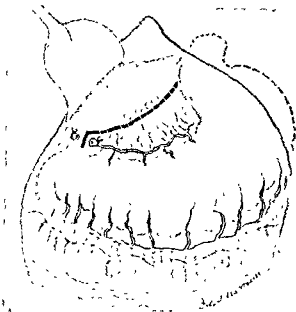


FIG 23 —Separation of gastro-hepatic omentum from liver

Duodenal transection

The duodenum is now transected at a convenient *level—but if the tumour* edge is within 3 centimetres *of the pylorus then at least* 3 centimetres of duodenum *must be excised. After the* duodenum is closed, the *stomach is turned up over* the left side of the wound and a retractor is placed *under the liver so that the left gastric vessels* come into view. After fine gastro-pancreatic adhesions are separated, the *left gastric vein and lymph glands are found first* with the left gastric artery behind, the whole being enclosed in a sheath of peritoneum—the "*falx coronarium*".

Division of left gastric pedicle

The lymph glands are separated from the right and left suprapancreatic glands and then stripped gently toward the stomach. The left gastric vein is isolated and divided. The left gastric artery is isolated, ligated with silk near its origin and then divided between artery forceps and ligated again. After a few peritoneal strands are freed the stomach can be lifted well up until the oesophagus comes into view. *All glandular and fatty tissue of the lesser curve* is now dissected from the part of the stomach to be retained. The tissue lying to the right of the oesophagus is *divided between artery forceps*, and after ligation the upper forceps is removed. The lower forceps is drawn downwards, stripping away *all the tissue down to the muscular coat of the lesser curve,* any vessels running into the stomach being ligated with fine silk or catgut (Fig 24). It is *remembered that lymphatics from the pyloric end of the*

stomach may enter the paracardial glands and any palpable or firm glands of this group are included in the stripped tissue. This dissection ceases at the level of the gastric transection and the stripped tissues are eventually removed with the stomach.

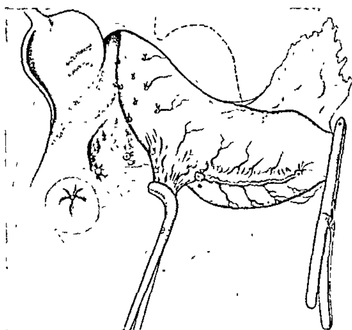


FIG 24.—Stripping all glandular and fatty tissue from lesser curvature from oesophagus down to the line of transection

On the greater curvature the gastro-colic omentum will have been separated from the colon and so the left gastro-epiploic vessels and vasa brevia are now tied and divided well away from the stomach until the level of transection of the greater curve is reached.

Level of gastric transection

The level of gastric transection should never be below the junction of the upper quarter and lower three-quarters of the stomach. Cancer cells are usually found 3 centimetres from the edge of a non-infiltrative type of growth and 6 centimetres from the infiltrative types, therefore for safety the transected level should also be at least 6 centimetres above any infiltrative type of growth. This means that in the majority of cases the transection line is not much below the level of the cardiac orifice. The transection level should be immediately below rather than immediately above the level of the cardiac orifice in doubtful cases, for the mortality of the resection is considerably less if a small rim of gastric tissue is left, and, of course, passing the cardia gives no special immunity from recurrence, for there is free lymphatic communication above and below the cardia.

Restoration of continuity

So far as the restoration of continuity is concerned, the surgeon will usually prefer some modification of the Polya operation. The Billroth I type of anastomosis is possible, but because much of the duodenal blood supply and of the duodenum itself will have been removed, a gastro-jejunal anastomosis is usually preferred.

(*b*) *Resection of the middle and upper stomach*

If the upper limit of the tumour is so high that a transoesophageal section is necessary a transthoracic approach is advisable This approach may be by

a left abdomino-thoracic incision, or by postero-lateral thoracotomy through a low rib space or low (ninth or tenth) rib bed. The abdomino-thoracic approach will be described.

Abdomino-thoracic approach

The patient should be securely fixed *on his right side, with the upper arm* pulled well forwards, and hips and knees flexed. He may be fixed in this position by sand-bags, and a strap or a wide strip of adhesive plaster passed round the patient just below the iliac crest and then round the table, holds him firmly. A low bridge under the lower ribs gives increased exposure, but it should be lowered for the wound closure. It is convenient to give the operation tablea slight dorsal tilt for the early part of the operation and a ventral tilt for the oesophageal anastomosis.

Preliminary abdominal exploration

A transverse abdominal incision is made, starting midway between umbilicus and xiphisternum and passing just over the left costal margin. This is deepened to open the peritoneum *in the same line. The growth and any*

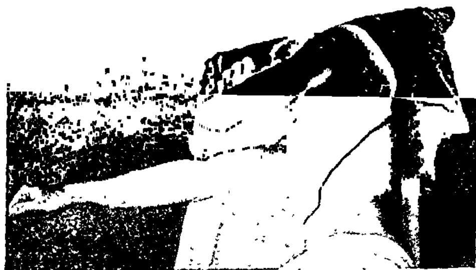


Fig. 25.—Line of the abdomino-thoracic incision.

[illegible] examined for

[illegible]

prolonged into the thorax (*Fig. 25*).

The thoracic extension of the incision

With the left hand in the abdomen, the eighth intercostal space is identified and over this space an incision is made from the costal margin to the pos- [illegible] ter- [illegible] ed [illegible] ent

A small length (about 1 centimetre) of the costal margin is [illegible] overriding after closure of the chest. Great care is taken to ligate or coagulate with diathermy every small bleeding point in the wound. As the thoracic *cavity is opened* a slow blood transfusion should be started to compensate at once for any blood loss.

A self-retaining abdominal retractor is placed in the wound and slowly opened out. The diaphragm *is now divided from* its periphery down to the oesophageal hiatus, several vessels in the muscle and finally the inferior phrenic vessels being ligated. The abdominal retractor is spread widely open (Fig. 26).

The decision must now be made as to whether total gastrectomy or merely a resection of the upper stomach is necessary. If the growth is localized to the reigon of the cardiac orifice, and the subpyloric glands are not enlarged, a resection of the upper three-quarters of the stomach is adequate, but if the

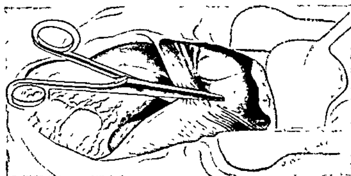


FIG. 26—The abdomino-thoracic approach The diaphragm being divided.

tumour is mid-gastric or involves over one-third of the stomach a total gastrectomy is more satisfactory. The spleen is routinely removed in tumours of the upper stomach in order to ablate the splenic group of lymph glands.

Splenectomy

The gastrectomy is commenced by separating the colon from the great omentum as described for tumours of the lower stomach, and this is continued to the splenic flexure. The spleen is now lifted forward and the splenic and left gastro-epiploic vessels are divided at the pancreatic tail, removing as many glands as possible with the spleen. The lateral peritoneum of the lesser sac is divided still higher in order to free the entire greater curve of the stomach up to the oesophagus. One or more vasa brevia are encountered which run from the course of the splenic artery as previously described (*see* Surgical Anatomy, p. 61) and will require division. The lower oesophagus is freed from the hiatus in the diaphragm, though if this part of the oesophagus is invaded by growth a ring of the muscular tissue of the diaphragm may be left attached to the oesophagus and removed with the growth. The glands round the cardia must be freed with the stomach.

Division of gastro-hepatic ligament

The upper limit of the gastro-hepatic ligament is now found and is divided from the liver, from the cardia downwards to the region of the hepatic artery, any small vessel being ligated carefully.

By rotating the stomach over to the right, the left gastric vessels are very clearly seen and are dissected and divided close to the pancreas, as previously described.

The dissection is now carried to the pyloric part of the stomach. If total gastrectomy is required, the division of the right gastric vessels and of the duodenum will be much as described for the lower stomach. If the pyloric part of the stomach is to be preserved then the right gastric and right gastro-epiploic vessels are divided just to the right of the site of the proposed gastric section. The stomach is then divided between Payr crushing clamps.

Mobilization of the oesophagus

The mediastinal pleura overlying the lower oesophagus is then divided and the ligamentum latum pulmonale is also divided for 5–6 centimetres. The level of division of the oesophagus is defined—it should be some 6 centimetres above the growth—and the oesophagus is gently freed for

3–4 centimetres above this point, any mediastinal glands or cellular tissue being dissected free and lifted up with the oesophagus.

The stomach and spleen and omenta are now lifted upwards and out of the wound. The oesophagus can be divided between fine (Lang-Stevenson) clamps and the growth removed, though some operators prefer to retain the stomach until the two posterior layers of the anastomosis are completed.

(*c*) *Reconstruction after resection of the upper three-quarters of the stomach*

Oesophago-gastric anastomosis

Continuity may be restored either by end-to-end oesophago-gastric anastomosis or by closing the cut end of the stomach and implanting the oesophagus into an opening made in its anterior wall. In either case the pyloric part of the stomach must be carefully mobilized. It is freed from the colon, and from the pancreas, and adhesions of parietes or gall-bladder to the duodenum are freed. It will usually be found that the stomach can then be lifted up until its cut end reaches the oesophagus without tension. If end-to-end anastomosis is to be made (and this has been found a safe method) then a short part of each extremity of the cut end of the stomach is closed until the residual opening equals the size of the oesophagus (Fig. 27 (a)). A continuous fine catgut stitch unites the posterior sero-muscular layer of stomach to the muscular layer of the oesophagus. An "all-the-coats" suture is now placed between posterior and then anterior layers of stomach and oesophagus, using fine interrupted silk sutures and taking great pains to get a good "bite" of

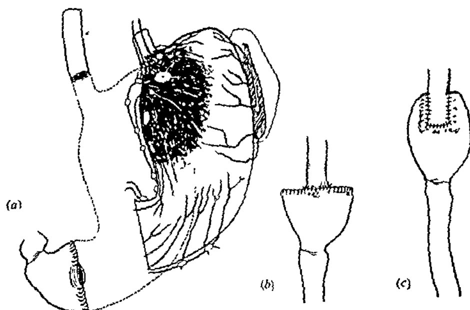


FIG. 27.—(*a*) Oesophago-gastric anastomosis. Closure of each extremity of the cut end of the stomach. (*b*) The "all coats layer" completed. (*c*) The two projecting parts of the stomach are stitched against the side of the oesophagus.

oesophageal mucosa in each stitch (Fig. 27 (b)). It must be remembered that in all oesophageal anastomoses, particularly those performed with some tension in the oesophagus, the mucosa tends to disappear upwards and its absence may pass unnoticed. The catgut continuous suture is now continued round the oesophagus in such a way as to stitch each jutting-out corner of the stomach against the side of the oesophagus (Fig. 27 (c)). A few interrupted reinforcing sutures of silk complete the anastomosis.

(d) Reconstruction after total gastrectomy

It is occasionally possible to unite duodenum to oesophagus but, as this tends to make the operator less radical in his resection, it is not advised.

Oesophago-jejunal anastomosis

The more usual method of anastomosis is either one of the methods of end-to-side oesophago-jejunostomy or end-to-end oesophago-jejunostomy. End-to-side oesophago-jejunostomy implies a two-layer or three-layer anastomosis of cut end of oesophagus to a transverse incision in the jejunum, with or without short-circuiting the proximal and distal jejunal loops. If the loop is too short to reach the oesophagus one or two of the main jejunal vessels may be divided as suggested by Sweet (1943)—this gives an extra length of 2–3 centimetres to the mesentery.

Graham's modification

Leakage has not been uncommon after this procedure and Graham's modification is safer (Graham, 1940). The jejunal loop is first sutured to the posterior margin of the oesophageal hiatus. The oesophagus is sutured end-in-side to the efferent loop of jejunum (Fig. 28 (a)) and the afferent loop is then

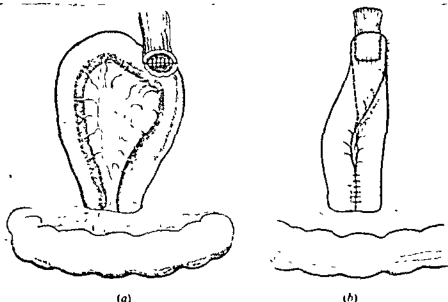


FIG 28.—Graham's method (*a*) The afferent loop of jejunum is fixed behind the oesophagus and then the oesophagus anastomosed to it. (*b*) The anastomosis is covered by stitching the afferent loop of jejunum over it

brought round to cover the front of the anastomosis, so that the chance of leakage is diminished because the anastomosis is enclosed between the two lengths of jejunum (Fig. 28 (b)).

Lefevre's modification

Another variant of the operation is that recommended by Lefevre (1946). A loop of jejunum is taken, the jejunum at the apex is transected and the two ends are closed (Fig. 29 (a)) The efferent loop is fixed behind the oesophagus and an end-in-side oesophago-jejunostomy is made into its anterior surface (Fig. 29 (b)) The afferent loop is then stitched to the front of the anastomosis so that the anastomosis is sandwiched between the loops even more snugly than by the preceding method A short-circuiting of the loops is, of course, essential (Fig. 29 (c)).

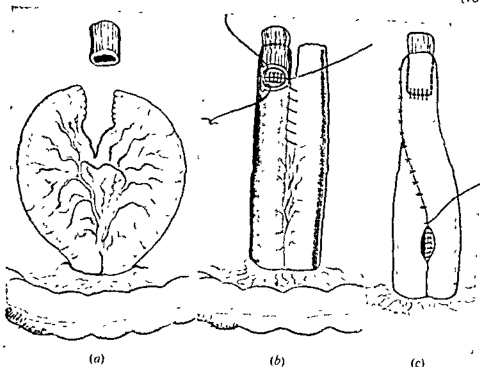


FIG 29.—Lefevre's method. (*a*) The jejunum is transected and its two ends closed. (*b*) An anastomosis is made into the efferent loop after fixing it behind the oesophagus. (*c*) The afferent loop is fixed in front of the anastomosis and the loops are short circuited.

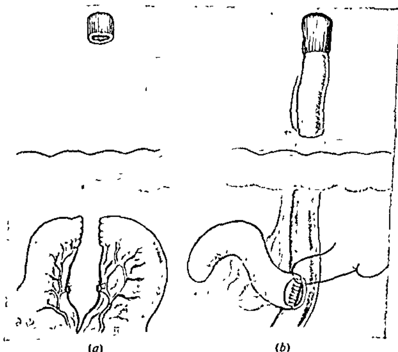


FIG 30.—End-to-end oesophago-jejunostomy (*a*) The jejunum is transected and the efferent loop mobilized by division of a jejunal vessel. (*b*) End-to-end anastomosis of efferent loop to oesophagus with end-in-side jejuno-jejunostomy

End-to-end oesophago-jejunostomy

End-to-end anastomosis of oesophagus to jejunum is probably the ideal procedure (Fig 30 (a)). The jejunum is transected some 12 inches past the

duodeno-jejunal junction. The efferent loop is lifted up through the mesocolon and the diaphragm and is sutured end-to-end to the oesophagus, so that the oesophagus is slightly invaginated into the jejunum (though with accurate mucosa-to-mucosa suturing). The afferent cut end of jejunum is anastomosed end-in-side to the efferent loop at a convenient site lower down (Fig. 30 (b)) The efferent loop of jejunum is often too short to reach the oesophagus, in which case it must be mobilized by dividing one or two of the main jejunal branches of the superior mesenteric artery (Roux).

(e) *Avoidance of tension on the anastomosis: completion of operation*

No matter which type of anastomosis has been performed, it must be without tension, or it may leak. To remove tension, the stomach or jejunum, whichever is anastomosed to the oesophagus, is lifted firmly upwards until the suture line is without tension, and then is sutured with many fine interrupted silk sutures to the cut edge of the mediastinal pleura or even to the

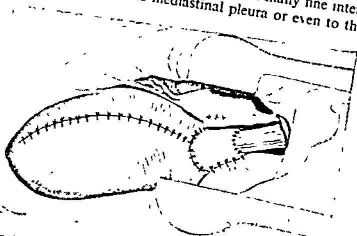


FIG. 31.—The viscus anastomosed to the oesophagus is stitched to the mediastinal pleura to take off any tension, and also to the diaphragm to prevent herniation

pleura lateral to the aorta—whichever is most convenient (Fig. 31). The mediastinal pleura should not be closed, however, for any exudates from the mediastinum must be free to drain into the left pleural cavity. Penicillin powder should be dusted round the anastomosis and in the adjacent mediastinum.

Closure of diaphragm

The abdominal retractors are now removed and the diaphragm is closed, a continuous stitch being used, with fine interrupted silk sutures to reinforce the closure. A fairly generous opening should be allowed for the stomach or jejunum to pass through the posterior part of the diaphragmatic incision, and the viscus passing through is sutured with fine silk to the diaphragm to prevent herniation of abdominal contents into the thorax (Fig. 31).

The abdomen and the intercostal incision are then closed in the usual way, without drainage.

(f) *Management of extra-gastric extension of carcinoma*

Extension of carcinoma through the gastric wall into contiguous structures usually occurs in growths which are too diffused to be resectable, but occasionally a tumour will be encountered which appears to penetrate deeply and yet to remain fairly localized, and in such a case resection of the neighbouring organ may be worth while.

Invasion of colon and mesocolon

Invasion of the mesocolon is common in pyloric antral carcinoma. In such a case the affected mesocolon may be excised, and the middle colic artery may also have to be resected, but the marginal artery should be spared if it is not actually invaded by growth. At the completion of the gastrectomy the colon is inspected; it is usually found to be viable and all that is necessary is to repair the mesocolon. If it is discoloured and the vessels have ceased to pulsate, the affected colon must be excised by one of the orthodox methods. At times the colon itself is infiltrated with growth and may be resected.

High anterior tumours may invade the liver and either a wedge of liver tissue or a part of the left lobe can be excised with the stomach, after placing interrupted mattress sutures just beyond the line of section, and dividing the left triangular ligament.

Invasion of the abdominal wall is treated by excision of an appropriate area of the parietes.

Invasion of the lesser sac

A not infrequent type of posterior penetration of gastric carcinoma is into the peritoneum of the lesser sac or into the pancreas. If the head of the gland is involved a small superficial layer may be shaved off, or its peritoneum stripped off If the body or tail is invaded, this part may be removed with the stomach. There is an additional advantage to be gained by removal of the body and tail of the pancreas in upper gastric carcinoma, in that many of the suprapancreatic glands along the splenic and round the coeliac artery are removed.

If the body and tail of the pancreas are to be removed the operative procedure must be varied After the great omentum is freed from the transverse colon, the lienorenal ligament is divided and, from here, dissection is continued to the right behind the peritoneum of the lesser sac. The stomach, spleen,

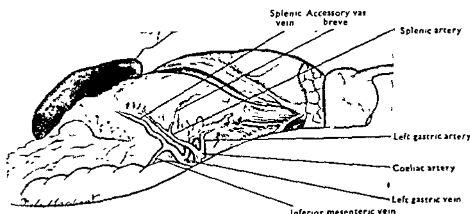


FIG. 32.—Stomach, spleen, pancreas and lesser sac are lifted forward and the origins of the splenic and left gastric arteries come into view.

lesser sac of peritoneum, and body and tail of pancreas are thus lifted forwards, leaving the adrenal gland and perinephric tissue behind (Fig 32). The origins of the left gastric and splenic arteries are found, tied and divided. The pancreas is transected just to the left of the junction of the inferior mesenteric vein with the splenic vein. The pancreatic duct is tied, the anterior and

posterior parts of the cut edge of the pancreas are sutured together with interrupted fine silk mattress stitches, and the area is drained. From this point the gastrectomy proceeds as described.

(13) Post-operative care

Shock may follow some of the extensive resections and should be prevented as far as possible by early transfusion.

If the pleural cavity has been opened, it will be necessary to aspirate any collection of fluid from it daily until it is dry.

Bronchial secretions In upper abdominal operations and particularly after thoracotomy it is necessary to encourage coughing to expel any excessive bronchial secretion The best time for this is shortly after an injection of morphine. Aspiration of the bronchus is occasionally necessary if the patient cannot expel the secretions; this may be done blindly, using a No. 16 French rubber catheter (Haight, 1938), or under vision through a bronchoscope.

Post-operative feeding The management of feeding after a resection of carcinoma of the lower stomach is the same as after resection for ulcer. If total gastrectomy has been performed, the main fluid intake for 2 or 3 days will be by the intravenous route. It is safe to start mouth feeding 24–48 hours after an oesophageal anastomosis and one should aim at giving some egg and milk from the third day. If nausea or regurgitation occurs a small oesophageal tube should be passed to empty the gastric remnant or the jejunum and oral feeding should be discontinued for 24 hours.

(14) Results of treatment

The results after resection of the stomach have been discussed under prognosis. It should be mentioned, however, that since 1939 there has been a revolutionary change in the results of the treatment of carcinoma of the upper stomach, because the immediate mortality for total gastrectomy has dropped from something over 90 per cent in 1939 to figures of between 10 and 40 per cent, depending partly upon the type of risk accepted.

The patient after total gastrectomy is almost as comfortable as the patient with partial gastrectomy. The addition of pancreatectomy to a total gastrectomy leads to a slight looseness of the bowels but this settles after a few months.

6. SARCOMA OF THE STOMACH

(1) Definition

Sarcoma of the stomach may arise as a primary tumour in the stomach or may be the result of degeneration of a benign tumour.

(2) Aetiology

Sarcoma is said to account for 1 per cent of all gastric tumours; it appears at any age, affecting young people more often than does carcinoma.

(3) Pathology

About one in eight leiomyomas shows sarcomatous change, but it is very difficult to differentiate the benign from the malignant tumours (Golden and Stout, 1941) In the malignant form the tumour cells are not so fully differentiated as in the benign form, and the fusiform cells are shorter, rounder, a

irregular in form. The tumour usually ulcerates but has similar gross appearances to the benign form.

Sarcomatous degeneration occurs at times in gastric neurofibromas, but there is some doubt whether the neurilemmoma ever becomes malignant.

Lymphosarcoma and reticulosarcoma may arise in the lymphoid tissue of the stomach. The typical microscopic features are found, and the tumour may appear to be multicentric in origin. Irregular and perhaps multiple ulceration may occur (Plate III, Fig. 1).

Round-cell and spindle-cell sarcomas which do not conform to these groups are also described.

(4) Clinical picture

The onset may be similar to that of gastric carcinoma or to that of benign gastric tumour. The features more typical of gastric sarcoma are anaemia due to obvious or occult bleeding, epigastric pain and the presence of an epigastric mass. Cervical, axillary or inguinal glandular enlargement may occur in association with lymphosarcoma.

(5) Special aids to diagnosis

The blood picture is usually one of severe secondary anaemia. Rarely a leukaemic blood picture is found—it is probably correct to consider lymphatic leukaemia as a form of lymphosarcoma.

Radiological findings

Radiologically, gastric sarcoma may resemble benign tumour. More commonly the findings are indistinguishable from those of carcinoma, although the duodenum may be infiltrated in lymphosarcoma. If the tumour is exogastric, for example, a subserous polypoid form, then the radiological findings may be negative.

Gastroscopy

The gastroscopic appearances of leiomyosarcoma are usually the same as those of the leiomyoma, though there may be thickening of the folds passing from the tumour to the surrounding mucosa, and ulceration is almost invariably present.

Lymphosarcoma cannot be differentiated from ulcerating carcinoma gastroscopically.

(6) Differential diagnosis

Infiltration of the gastric mucosa may occur in Hodgkin's disease and leukaemia, but these diseases are probably forms of lymphosarcoma.

Differentiation from carcinoma may be impossible unless a gland is available for biopsy, though sarcoma should be suspected in a youthful patient.

Differentiation between the benign and malignant connective-tissue tumours is usually difficult, but rapid growth in size is suggestive of malignancy.

(7) Prognosis

The prognosis of leiomyosarcoma after local resection is good, for the tumour is of very slow growth and hardly ever metastasizes to the liver or lymphatic glands.

Lymphosarcomas have a poor prognosis even after resection; though good results may be obtained by deep x-ray therapy, for the tumours are usually radio-sensitive.

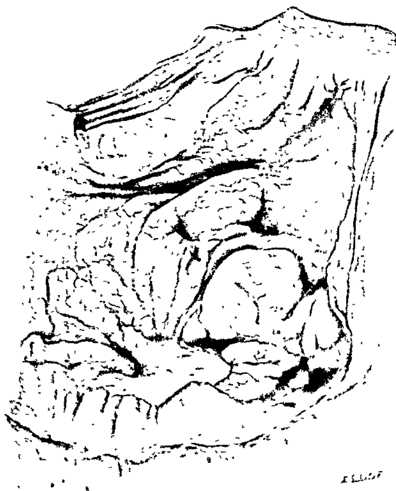


FIG. 1.—Reticulosarcoma of stomach. Note the two separate ulcerating areas.

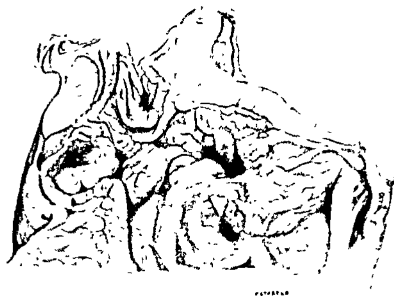


FIG 2—Resected adult stomach with hypertrophy of the pyloric muscle.

PLATE III

(8) Indications for surgical treatment

The leiomyosarcomas and other sarcomas apparently developing from benign tumours should always be removed in view of their dangers and the good operative prognosis.

Resection is worth while if a lymphosarcoma is well localized, but the diagnosis is not usually made until a resection for an apparent carcinoma is performed. If the tumour is considered unresectable, a course of deep x-ray therapy should be given, and even after resection the area of operation should be irradiated.

(9) Surgical treatment

In the cases of sarcomas resembling benign tumours, in particular the leiomyosarcoma, a local excision is adequate, and cure may follow mere ligation of the pedicle of a pedunculated sarcoma. If there is any induration of the base a wider resection is necessary—removing a cuff of gastric wall, or partial gastrectomy, whichever is more convenient.

The lymphosarcomas will usually be treated on the same lines as gastric carcinoma. Once the diagnosis has been made, whether before or after operation, a course of deep x-ray therapy is given, particularly if the tumour is of the small round-cell (lymphocytoma) type, for this is more radio-sensitive than any other gastric tumour.

7 HYPERTROPHY OF THE PYLORIC MUSCLE IN ADULTS

(1) Definition

A rare form of gastric obstruction in adults is due to hypertrophy of the pyloric muscle.

(2) Aetiology

The condition may be found in either sex and at any age (Maier, 1885). It may occur alone or in association with other gastric lesions, notably gastric ulcer. It is possible that the condition may result from congenital pyloric stenosis, for some patients give a history of epigastric disturbance and vomiting dating from childhood Another possibility is that it results from autonomic nervous imbalance

(3) Surgical anatomy

There is a good deal of variation in the thickness of the normal pyloric muscle. Horwitz, Alvarez and Ascanio (1929) measured it in a group of 47 adults and found that it varied between 3·8 and 8·5 millimetres in diameter.

(4) Pathology

The pyloric muscle may increase in size in the presence of a gastric ulcer and it is difficult to say which is the primary lesion, for it is possible that the ulcer causes pylorospasm which leads to hypertrophy. *Association with gastric ulcer*

Examination of the pylorus in uncomplicated hypertrophy shows simple hypertrophy of the circular muscle fibres with some exaggeration of the pyloric mucosal folds

The ease with which the muscle fibres can be divided with a blunt dissector in cases of congenital pyloric stenosis is not a feature of the adult variety.

(5) Clinical picture

In some cases there is a history of epigastric pain and vomiting dating from childhood. Others present with a short history suggestive of pyloric obstruction. The majority, however, give a long history resembling that of peptic ulcer, commencing in adult life.

Wasting may occur but is not usually pronounced. Visible gastric peristalsis is sometimes seen. The thickened pylorus cannot be felt through the intact abdominal wall.

(6) Special aids to diagnosis

Radiological examination will show an elongated narrowing of the pyloric canal, with intact mucosal folds. At times a concavity is seen at the base of the duodenal cap, due to the invagination of the hypertrophied pylorus (Kirklin and Harris, 1933). There is delay in emptying the stomach.

Gastroscopy is valuable as a means of excluding carcinoma of the pylorus.

(7) Differential diagnosis

The differentiation from stenosing duodenal ulcer depends upon the radiological examination and perhaps upon the lack of a history of ulcer. Differentiation from carcinoma is reasonably certain if good gastroscopic views of the pyloric movements are obtained, and appear normal.

(8) *Indications for surgical treatment*

Most cases are not diagnosed before laparotomy. If, however, the condition is suspected and carcinoma is excluded a preliminary course of rest and gastric lavage may be given. If pyloric obstruction persists, then surgery is indicated.

(9) Operative technique

Resection

On palpation of a firm mass in the pylorus, particularly with a short history of obstructive symptoms, carcinoma is suspected, and resection is often undertaken (Plate III, Fig. 2). If gastric ulcer is also present, gastric resection is advisable even if carcinoma is not suspected.

Pylorotomy

Pyloroplasty

Simple pylorotomy—the Fredet-Rammstedt procedure—is inadvisable because of the risk of overlooking malignant disease. It is, however, a sound procedure to make a longitudinal incision through all coats of the pylorus and adjacent duodenum down through the mucosa, inspect the sectioned muscle and the pyloric mucosa, take a piece for biopsy and resuture the incision transversely (Heineke-Mikulicz pyloroplasty). By this means, the presence of carcinoma will not be overlooked

(10) *Results of treatment*

Gastrectomy gives good results and freedom from symptoms. Pyloroplasty as described above has also given excellent results

8. GASTRIC DIVERTICULUM

(1) *Aetiology*

True gastric diverticulum is most commonly found in middle life but it has been described in infancy and is occasionally seen in young adults (Schwalbe,

1912; Sinclair, 1929). It may be congenital and is sometimes associated with duodenal or colonic diverticula.

False or acquired diverticulum is of the pulsion or the traction variety. The latter is more common and may result from adhesion of the stomach to a neighbouring organ, or to the pull of a subperitoneal pedunculated simple tumour.

(2) Pathology

True diverticula are commonest high on the posterior part of the lesser curvature of the stomach and are but rarely found lower down or near the pylorus. The wall is of gastric mucosa and thinned-out muscle covered with peritoneum.

Associated lesions

Associated lesions are sometimes found—for example, atrophic gastritis, or peptic ulcer. It is perhaps truer to say that in investigating these associated lesions a symptomless diverticulum may be found.

(3) Clinical picture

The majority of gastric diverticula are symptomless. Occasionally complaints are made of epigastric or substernal discomfort after meals, and pain may be experienced during the act of swallowing. Massive haemorrhage rarely occurs.

(4) Special aids in diagnosis

Radiological examination shows a smooth out-pouching with a narrow neck communicating with the stomach (Fig. 33 (a)). A fluid level capped by air may be seen when the patient is in the erect position Barium may be retained in the diverticulum for as long as 24 hours (Fig. 33 (b)) (Buckstein, 1948c).

Gastroscopic findings

The smooth mouth of the diverticulum may be clearly seen on gastroscopy (Plate I, Fig. 2 (b)), and one may even see a pool of mucus lying inside it. A fold from the stomach may be seen to enter the diverticulum.

(5) Differential diagnosis

Diverticulum may be distinguished from ulcer by its smooth outline and the variation in shape during peristalsis. Gastroscopy leaves little room for doubt in the majority of cases. If doubt is felt, however, re-examination after the patient has had 10 days' rest in bed will usually show diminution of the size of an ulcer, but a diverticulum will be unaltered

(6) Indications for surgical intervention

Treatment is not required for the symptomless diverticulum or for the one with minimal symptoms, beyond moderation of the diet If persistent dyspepsia or recurrent bleeding or dysphagia occurs, surgical treatment is recommended.

(7) Operative technique

Even a diverticulum near the cardiac orifice may be approached satisfactorily by an upper abdominal incision. It is usually found between the layers of the gastro-hepatic omentum.

Small diverticula may usually be treated by invagination and repair of the muscular defect at the base. If, however, a large diverticulum just below the cardia is so treated, it may obstruct the cardiac orifice like a ball-valve and

prevent expulsion of air from the stomach, particularly if bleeding occurs into the invaginated mucosa. Such an operation has been known to result in severe persistent gastric distension. Therefore a diverticulum in this situation is best treated by careful excision and repair of the resulting defect. *Excision and repair of defect*

(8) Results of treatment

Relief usually follows excision in those cases in which the diverticulum was correctly diagnosed as the cause of the symptoms.

9. VOLVULUS OF THE STOMACH

(1) Definition

Volvulus of the stomach is a torsion or rotation of the stomach which may occur round the axis of the stomach itself (organo-axial volvulus), or more commonly round the axis of the gastro-hepatic omentum (mesenterio-axial volvulus).

(2) Aetiology

The condition occurs at any age and in either sex, and laxity of the ligamentous supports predispose to it. Other exciting causes are diaphragmatic, particularly hiatal hernia, eventration or paralysis of the diaphragm (Fig. 34) or adhesion to the stomach round which it rotates.



FIG 34.—Partial volvulus following diaphragmatic paralysis due to phrenicotomy. Periodic bouts of vomiting were complained of.

(3) Surgical and pathological anatomy

Rotation through 180 degrees may be symptomless, but complete rotation through 360 degrees may occur. In chronic volvulus the pyloric part of the stomach usually rotates in front of the fundus.

In acute volvulus gastric obstruction and, later, vascular occlusion and gangrene occur.

(4) Clinical picture

A lesser degree of volvulus may be associated with vague dyspepsia or bouts of vomiting

Acute volvulus presents as an acute abdominal catastrophe, with severe epigastric pain, vomiting and collapse. On examination the upper abdomen may be found to be distended and is extremely tender and rigid.

(5) Indications for surgical treatment

Surgery is indicated in the partial forms of volvulus only if incapacitating attacks of pain or vomiting are frequently repeated. The acute form is treated as an acute surgical emergency.

(6) Operative technique

Untwisting of the volvulus is all that is required in the acute form unless definite necrosis makes a sleeve resection necessary.

In the subacute or partial forms any predisposing lesion is dealt with, for example, hiatal hernia or gastric adhesion. To prevent recurrence, shortening of the gastric ligaments, fixation of stomach to liver or parietes, or rarely a gastrectomy may be required. If the diaphragm is high it is helpful to free the transverse colon from the stomach by division of the gastro-colic *omentum. When the stomach is then fixed, for example to the liver,* the colon can freely ascend to fill the subphrenic region and will not tend to pull the stomach with it.

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STRABISMUS AND HETEROPHORIA

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1. DEFINITION

313.] Strabismus may be manifest or latent.

Heterotropia In a case of manifest strabismus (heterotropia) the visual axis of one eye only is directed towards the point of fixation, that of the other eye deviates.

Deviations The deviation may be horizontal or vertical. If horizontal, it may be convergent (esotropia) or divergent (exotropia). If vertical, it may be sursumvergent (hypertropia) or deorsumvergent (hypotropia). A combination of horizontal and vertical deviation may exist. Strabismus may be unilateral or alternating, and in either case it may be constant or intermittent. If constant, it may vary in degree according to circumstances.

Heterophoria In a case of latent strabismus (heterophoria) both visual axes are normally directed towards the point of fixation, but if one or other eye be occluded (cover test) the occluded eye deviates. If no deviation occurs the state of affairs is called orthophoria, but true orthophoria for all distances and for *Orthophoria* all directions of the gaze is rare, and a slight deviation of the occluded eye is common. Normally, however, there is a rapid resumption of binocular fixation when the occluder is removed, indicating that the deviation is fully compensated. Convergent deviation of the occluded eye is described as esophoria, divergent deviation as exophoria, and vertical deviation upwards and downwards, as hyperphoria and hypophoria respectively.

If the deviation under cover is large in degree, and is associated with slow recovery of binocular fixation on removal of the occluder, difficulty may be experienced in maintaining binocular single vision, and symptoms of ocular fatigue (and sometimes, intermittent strabismus) may occur, showing that the latent deviation is not fully compensated.

Defects of binocular functions Apart from the loss of binocular single vision, which must obviously occur when a manifest strabismus is present, various defects of the binocular functions, such as ocular neglect or suppression, are usually associated with the presence of strabismus, whether it be manifest or latent. For the most part they are the result of the strabismus, although in some cases they may pre-exist and be causative factors.

2. AETIOLOGY OF STRABISMUS

Manifest strabismus (heterotropia)

(*a*) *Acquired "paralytic" strabismus*

This condition, mostly occurring in adults, is one in which deviation of the visual axis of one eye may occur as a result of: (i) paralysis or paresis of one or more of the extrinsic ocular muscles. This may be due to disease or injury of the muscle itself, or of the nerve which supplies the muscle;

(ii) mechanical displacement of the eyeball due to local injury to, of, the orbit.

Diplopia

In these cases, owing to the fact that normal binocular single usually existed before the onset of strabismus, diplopia is invariabl

(b) *Concomitant strabismus in infancy*

In the absence of any gross ocular palsy, deviation of the visual occur as a result of: (i) a sensory obstacle, (ii) a motor obstacle, central obstacle, or as a result of a combination of two of these, or o

Acquired function

(i) *Sensory obstacles.*—It is generally considered that the power of vision, that is, the ability of the brain to fuse the two similar visual im formed on corresponding points of the retinae, is an acquired its development being dependent upon the normal anatomical an logical development of the whole of the visual apparatus. Thus in infant the function of binocular vision is ill-developed, in fact it is not until the fifth year of life that the binocular reflexes are fully d

The anatomical position of rest of the visual axes is one of slight d and sursumvergence, but the visual axes are maintained in thei alignment because of a desire for binocular vision with its rew appreciation of depth and perspective. It follows, therefore, that a which interferes with the formation of similar images on the two may prevent the proper development of binocular vision, and hence c may occur. Such a factor may be described as a *sensory obstacle*, e of which are temporary occlusion of one eye, errors of refraction (e associated with anisometropia) and organic defects in the media or

Defects of ocular muscles

(ii) *Motor obstacles.*—These consist of defects of the ocular mus other mechanical factors which may cause deviation of one of the visu Paralysis or paresis of an extrinsic ocular muscle may occur in an i either a congenital or acquired defect, but because binocular v ill-developed and suppression of one image easily occurs, diplopia i obvious symptom. Furthermore, a slight and transient paresis of a muscle, which might only cause heterophoria in an adult, may be s to cause heterotropia in an infant by severing the slighter bonds whi the two eyes at that stage of development.

(iii) *Central obstacles.*—In addition there may be various central o such as psychological trauma.

It is likely that in many cases of strabismus in infancy there is more t cause and it should be remembered that the hereditary and familial f an important one.

Errors of refraction

Although errors of refraction have been mentioned under sensory ob as a cause of squint, further elaboration is needed to explain the relat of such errors of refraction to the type of deviation present.

(c) *Convergent strabismus in infancy*

This condition may be due to the following factors.

Contraction of ciliary muscle

(i) *A moderate degree of excessive hypermetropia.*—An attempt to ove the hypermetropia and to obtain clear vision is made by contr of the ciliary muscle (which is not fully developed in the infant). to the normal association of accommodation and convergence, an exc

accommodative effort tends to be associated with over-convergence, and hence may cause convergent strabismus. In some cases correction of the refractive error may cure the squint.

(ii) *Congenital myopia of moderate degree.*—In this condition, the only ocular posture in which the infant sees clearly, and binocularly, is one of convergence This necessitates no accommodative effort. The image of a distant object is blurred and there is little or no advantage in seeing one rather than two blurred images, hence as binocular vision for distance is relatively unrewarded, the convergent posture of the eyes persists.

Correction of the refractive error usually increases the angle of deviation.

(*d*) *Divergent strabismus*

This may result from acquired myopia or acquired myopic astigmatism. *Acquired myopia* Here the physiological link of accommodation and convergence has already been formed at a definite level, and the onset of myopia results in disuse of accommodation. The resulting relaxation of the ciliary muscle causes an associated lack of convergence and hence a divergent strabismus may occur.

(*e*) *Congenital ocular palsy with retention of binocular vision*

In some cases of ocular palsy of congenital origin, especially if only one vertically acting muscle is involved, a manifest deviation of the visual axes may occur in certain directions of the gaze only. This causes a diminished field of binocular single vision, with suppression affecting one eye, or with diplopia, in the rest of the binocular field. In order that binocular single vision may be present when the gaze is directed in front, an abnormal head posture may be adopted. Such a condition is described as "ocular torticollis". *Ocular torticollis*

(*f*) *Secondary strabismus*

If a gross visual defect, due to the presence of some organic lesion, involves one eye, the affected eye tends to deviate. With certain exceptions the deviation is divergent if the defect dates from birth, convergent if the defect occurs in childhood, and divergent if the defect occurs in later adult life. *Incidence*

3. SURGICAL ANATOMY

Fig. 35 shows the anatomical arrangement of the extrinsic ocular muscles and their relationship, and the Table shows the action of the extrinsic ocular muscles Fig. 36 shows what may be described as the six diagnostic positions of the gaze, and the main muscles which are active in bringing the eyes into these positions.

4. PATHOLOGY

When an ocular muscle palsy occurs, certain sequelae take place. These are: (a) overaction of the contralateral synergist; (b) contracture of the direct antagonist; (c) secondary inhibitional palsy of the contralateral antagonist.

Thus in the case of palsy of the right lateral rectus muscle there occurs: (a) overaction of the left medial rectus; (b) contracture of the right medial rectus; (c) secondary palsy of the left lateral rectus.

A squint which commences as a paralytic one may eventually become more or less concomitant due to the development of these sequelae.

In the case of palsy of the right superior oblique muscle there is: (a) overaction of the left inferior rectus; (b) contracture of the right inferior oblique; (c) secondary palsy of the left superior rectus.

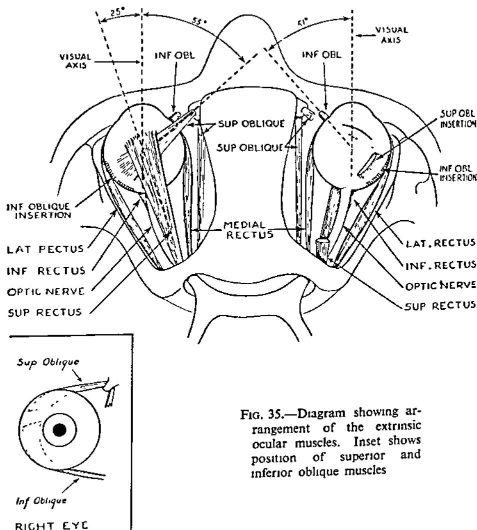


FIG. 35.—Diagram showing arrangement of the extrinsic ocular muscles. Inset shows position of superior and inferior oblique muscles

TABLE

ACTIONS OF THE EXTRINSIC OCULAR MUSCLES

The rectus muscles	*Main action maximum when eye is abducted*	*Subsidiary actions: maximum when eye is adducted*
Superior	Elevation	Adduction Intorsion
Inferior	Depression	Adduction Extorsion
	Main action	*Subsidiary actions*
Medial	Adduction	None
Lateral	Abduction	None
The oblique muscles	*Main action maximum when eye is adducted*	*Subsidiary actions: maximum when eye is abducted*
Superior	Depression	Intorsion Abduction
Inferior	Elevation	Extorsion Abduction

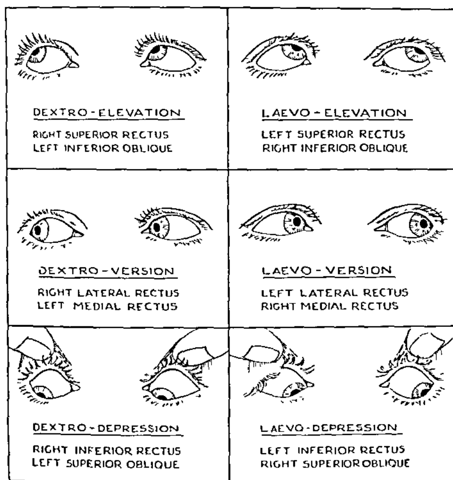


FIG 36—The six diagnostic positions of the gaze, and the muscles concerned

5. CLINICAL PICTURE

(1) Symptoms

(a) Squint

Deviation of the visual axes, which is more or less obvious depending upon its degree, is common to all varieties of manifest strabismus.

It is usually the only symptom in cases of strabismus which commences in infancy. The reason is that binocular vision being immature, its loss is relatively unnoticed and suppression of the image of one eye occurs so easily that diplopia is usually overcome.

(b) Diplopia

It must, however, be conceded that an infant may show signs of visual embarrassment at the onset of a squint, as evidenced by the intermittent closure of one eye. *Visual embarrassment*

In the case of an older child or an adult in whom the power of binocular vision is well developed, assuming that there is reasonable vision in each eye, the onset of a squint is associated with diplopia. If the squint is intermittent,

diplopia may or may not occur during the squinting phase, depending upon the presence or absence of suppression.

Types

Diplopia may be horizontal or vertical in type, depending upon the nature of the deviation.

(2) Signs

(a) *Ocular posture*

One eye may deviate constantly, or fixation may occur with each eye alternately, the other eye deviating. Sometimes one eye may be used predominantly for fixation, but not necessarily constantly.

(b) *Head posture*

Ocular palsy

In certain cases of ocular palsy, whether congenital or acquired, the defect may be such that a *manifest deviation only occurs in certain directions of* the gaze. The patient may, therefore, adopt an abnormal head posture in order to avoid turning his eyes towards the particular direction in which the deviation occurs.

(c) *Ocular movements*

Differentiation

In a typical case of truly concomitant strabismus of recent origin there is no limitation of ocular movement in any direction, whereas in a case of strabismus of paretic origin of recent onset, limitation of movement in the direction of the main action of the affected muscle is evident. A truly concomitant strabismus may, however, in the passage of time, acquire secondary incomitant characteristics, due to secondary musculo-fascial contracture. Conversely, in some cases of paralytic strabismus, in which recovery of the muscle has taken place, an angle of deviation, concomitant in nature, may remain, due to the presence of secondary changes.

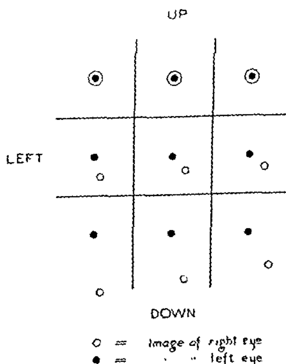


FIG. 37.—Diplopia chart—right superior oblique palsy.

(d) *Cover test*

Technique

This valuable test should be made using first a near, and then a distant, fixation object. The patient is asked to look at the object. The fixing eye is then covered and the deviating eye observed, so that the direction in which it moves in order to take up the fixation may be noted. This gives confirmatory evidence of the nature of

the angle of deviation. At this stage, the cover may be removed from the originally fixing eye and observation made to ascertain which eye is preferred for fixation, or whether fixation is alternating.

(*e*) *Diplopia test*

When diplopia exists, investigation of its nature and degree is a valuable aid to diagnosis. The essential things to discover are:

(1) The type of diplopia (whether vertical or horizontal).

(2) The direction of the gaze in which there is maximal separation of the images.

(3) The eye which corresponds to the "further-away" image in this direction (the further-away image obviously belongs to the eye with the defective muscle).

As an example, if reference is made to Fig. 37 it will be readily understood how in a case of right superior oblique palsy the diplopia is vertical with maximal separation of the images on laevo-depression, the lower image belonging to the right eye.

6. SPECIAL TESTS

(1) To ascertain the state and extent of binocular vision

A squint is not primarily of interest on account of its angle of deviation, but on account of the accompanying defect of binocular vision. The synoptophore or other type of amblyoscope, is essential for the investigation of the state of the binocular vision. Strabismus in an infant is invariably associated with such a defect to a greater or less extent. This may take the form of mental "suppression" or neglect of the retinal image of one eye, which may lead to amblyopia. The power of fusion and stereoscopic vision may gradually become defective, and in some cases abnormal retinal correspondence may develop. This is a condition in which the macula of the fixing eye is found to correspond with an area other than the macula of the non-fixing eye.

Synoptophore

Amblyopia

If binocular single vision is present in some directions of the gaze, tests should be carried out to ascertain the extent of the field of binocular single vision by means of the perimeter.

Perimeter test

(2) To measure the angle of deviation

The actual measurement of the angle of deviation is important, although it may vary considerably according to conditions such as: (a) the distance of the fixation point; (b) the method employed; (c) the direction of the gaze; and (d) the wearing, or otherwise, of glasses which correct the refractive error.

Apparatus such as the synoptophore, the perimeter, or the Priestley Smith tape, may be used objectively and can, therefore, be independent of anomalies of binocular vision. The use of prisms with the cover test is perhaps the most accurate method.

Priestley Smith tape

If sufficient power of binocular vision exists, the Maddox rod test (for distant vision), and the Maddox wing test (for near vision) should be used to measure the deviation. There are also certain other tests which give reliable information, provided that the patient is sufficiently co-operative. These are: (a) the Hess screen examination, whereby information is obtained as to the comparative activity of the extrinsic ocular muscles of the two eyes; and

Maddox rod and wing tests

(b) the Maddox rod chart whereby information is obtained of the ; angle of deviation in the nine cardinal positions of the gaze.

(3) General medical examination

Indications In any case in which a definite organic lesion is suspected as bei underlying cause of the squint, a complete medical examination, inc examination of the urine, is indicated. Other methods of examinatio also be required, for instance, serological examination of the blood, logical examination of the skull, and examination of the cerebrospina

7. DIFFERENTIAL DIAGNOSIS

Pseudo-strabismus

This means that the visual axes appear to deviate when such is not a the case. The condition may be caused by the following.

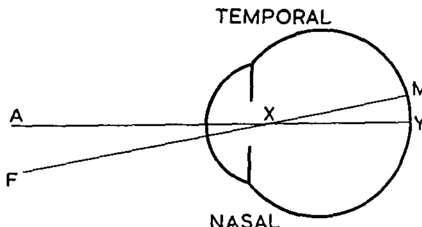


FIG 38.—Diagram to show a positive (normal) angle *alpha*: AY = optic axis, visual axis, AFX = angle *alpha*.



FIG. 39.—Pseudo-divergent strabismus of right eye due to a large positive (nasal) angle *alpha*

(a) Abnormalities in the r position of the orbits, due to genital anomalies or acquired d for example, orbits set widely with a resultant widening of the pupillary distance cause the appe of a divergent strabismus, and ort closely together with a resultant na ing of the interpupillary distance the appearance of a convergent ismus.

(b) Epicanthic folds of skin, esp if more pronounced on one side on the other, may cause a supe appearance of convergent strabism

(c) The presence of an abnor large *alpha* angle (the angle betwe visual axis and the optic axis) n positive (nasal), produce the appe of a divergent strabismus, a

negative (temporal) produce the appearance of a convergent strabismus (Fig. 38).

Fig. 39 shows a case in which pseudo-divergence of the right eye was caused by a large nasal *alpha* angle of 9 degrees. The Maddox rod test showed orthophoria at 6 metres. The correct diagnosis in such cases can easily be made by means of the cover test. *Diagnosis*

8. PROGNOSIS

With the exception of those cases of strabismus caused by an active or progressive organic lesion, and cases in which there is a more or less complete third cerebral nerve paralysis the prognosis is usually good, whatever the type of squint, provided that correct treatment is carried out from the onset.

9. TREATMENT

Treatment varies according to the variety of strabismus, but it may be summarized as follows:

(1) Concomitant strabismus in children

(a) Correction of refractive error

Correction of the refractive error (if relevant) by means of glasses may be indicated. In those cases of strabismus which are definitely related to the refractive error, this may cause the squint to disappear. This will be evident within a few days or weeks of wearing the glasses constantly.

(b) Occlusion of fixing eye

If the squint persists, in spite of glasses (or if there is no relevant refractive error) occlusion of the usually fixing eye is essential in order to prevent or overcome amblyopia, and to prevent or help to overcome abnormal retinal correspondence.

(c) Orthoptic treatment

When the visual acuity of the two eyes is equal, orthoptic treatment should be carried out (if the child is sufficiently old, that is, 4–5 years) in order to improve the power of binocular vision, and to overcome abnormal retinal correspondence if present, and then, if possible, to overcome the angle of deviation.

(d) Operative treatment

Operation is indicated if an angle of deviation persists in spite of orthoptic treatment, or if the child is too young for such treatment (the visual acuity of the two eyes having been equalized).

The earlier the onset of strabismus, and the older the child before the correct treatment is carried out, the worse the prognosis as regards obtaining binocular vision. The later the onset of strabismus and the shorter the squinting period before the correct treatment is carried out the better the prognosis. *Prognosis*

(2) Congenital ocular palsy

In a case of congenital ocular palsy with retention of binocular single vision in some directions of the gaze by means of the adoption of a compensatory head posture, the power of binocular vision is good, and if surgical treatment

is undertaken the prognosis is usually excellent, especially in conjunction with orthoptic treatment.

(3) Acquired ocular palsy

(a) Due to a lesion of a muscle or of its nerve supply

Adjustment of ocular muscles

Provided the condition is not due to active or progressive organic disease, the treatment is essentially surgical, consisting of the adjustment of one or more of the extrinsic ocular muscles, depending upon the case. In patients in whom the cause of the condition is due to head injury or is of obscure origin, an interval of time—4 months at least—should be allowed to elapse before surgical treatment is carried out, in order to allow for possible spontaneous recovery.

(b) Relative ocular palsy

Primary indication

This condition is due to mechanical displacement of the eyeball from fracture of the orbit. Although mechanical displacement of the eyeball does not invariably cause a deviation of the visual axes, it may do so. In such a case, restoration of the normal anatomy of the orbit, if this is possible, is indicated primarily. If this is not possible, or if a residual angle of deviation remains in spite of such treatment, adjustment of the ocular muscles should be carried out.

10. OPERATIONS FOR SQUINT

The aim of operation is to produce and maintain a condition in which both visual axes are directed, without conscious effort, to the object of fixation.

Result of operative treatment

Operative treatment should give a result in which the eyes not only appear straight, but in which both eyes look identical, and work together in all conjugate movements, and in the disjugate movement of convergence.

In order to obtain such a symmetrical result it is often necessary, especially in cases with a large angle of deviation, to perform operations upon both eyes rather than reduce such a deviation by operating upon one eye only.

Orthopaedic principles

Ocular muscles may vary considerably in size and development according to the case, so it is impossible to predict exactly how many degrees of deviation will be relieved by any one surgical procedure. Furthermore, the presence of muscle paresis and its sequelae (*see* Pathology, p. 91) are additional and variable factors, which must be taken into account. Therefore, squint operations often require to be performed upon orthopaedic principles, that is, in a series of stages In some instances an interval of several weeks may be allowed to elapse before further operation is performed, depending upon the nature of the case.

Classification

Operations may be classified as (1) those for convergent strabismus (2) those for divergent strabismus, and (3) those for vertical strabismus.

(1) Operations for convergent strabismus

The operations commonly employed in cases of convergent strabismus are:

(a) Operations designed to lengthen or weaken the medial rectus muscle.

(b) Operations designed to shorten or strengthen the lateral rectus muscle.

(a) Medial rectus muscle

Lengthening or weakening of the medial rectus may be done by one of the following methods.

(i) *Recession or retroplacement.*—The tendon of the muscle is severed from the globe at its insertion, and re-attached to the sclera farther back (Fig. 40 (a)).

(ii) *Marginal myotomy.*—In this operation the muscle is weakened by means of a series of vertical incisions into its upper and lower margins (Fig 40 (b)).

(iii) *Guarded tenotomy.*—The tendon of the muscle is severed from the globe at its insertion and prevented from receding too far into the orbit by means

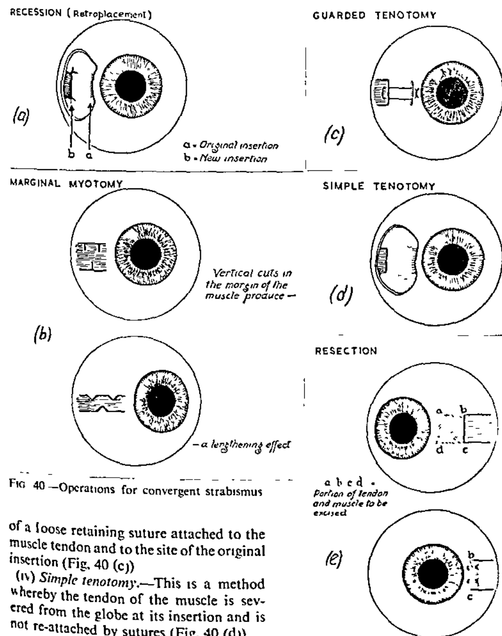


FIG 40 —Operations for convergent strabismus

of a loose retaining suture attached to the muscle tendon and to the site of the original insertion (Fig. 40 (c))

(iv) *Simple tenotomy.*—This is a method whereby the tendon of the muscle is severed from the globe at its insertion and is not re-attached by sutures (Fig. 40 (d))

(b) *Lateral rectus muscle*

Shortening or strengthening of the lateral rectus may be c one of the following methods.

(i) *Resection.*—The severed tendon of the muscle from which a varying amount of the distal portion, depending on the effect required, has been excised, is re-attached to its original insertion (Fig. 40 (e)).

(ii) *Advancement.*—In this method the tendon of the muscle is severed from the globe at its insertion and re-attached to the sclera farther forward.

A combination of advancement with resection may be performed to produce an enhanced effect.

(iii) *Tucking or tenoplication.*—The muscle or the tendon is folded upon itself and the folds are firmly stitched together so as to produce a shortening effect. It may be necessary to fold both muscle and tendon.

Muscle palsy

If the squint is associated with muscle palsy, due, for instance, to a paresis of the left lateral rectus muscle, in conjunction with which there is overaction of the right medial rectus muscle, a better result may be obtained by doing a right, rather than a left, medial rectus recession.

(iv) *Muscle graft operation.*—If the squint is due to a complete paralysis of the lateral rectus muscle with inability to abduct the affected eye beyond the midline, a "muscle graft" operation is indicated. A slip of muscle is detached from the outer third of the superior rectus muscle and another slip of similar size from the outer third of the inferior rectus muscle. These are then stitched to the sclera underneath the insertion of the paralysed muscle (Hummelsheim's, O'Connor's, or Temple-Smith's operation). It is important to keep the muscle slips absolutely taut, and it is desirable in addition to shorten the paralysed muscle by resection, and to lengthen the direct antagonist by recession.

(c) *General principles*

Some general principles for the operative treatment of convergent strabismus are appended.

(1) In children, and in adults if a binocular result is envisaged, it is unwise to retroplace the insertion of the medial rectus tendon more than 5-6 millimetres, otherwise there is a risk of convergence weakness resulting.

(2) The average effect of a 5 millimetre recession of the medial rectus is to reduce the angle of deviat on by 7–10 degrees, and the average effect of suc an operation combined with a 5 millimetre resection of the lateral rectus o the same eye is to reduce the angle of deviation by about 20 degrees.

(3) If the squint is of long standing any surgical procedure has less effect than it does if the squint is of more recent origin.

(4) It is unwise to perform a free tenotomy of the medial rectus of a child, and if the angle of deviation exceeds 30 degrees the operative treatment should invariably be divided between the two eyes, otherwise an asymmetrical result occurs.

(2) Operations for divergent strabismus

The principles of operative treatment in these cases are similar to those indicated for convergent squints. The operations consist of advancement or resection of the medial rectus, or recession or tenotomy of the lateral rectus; in some cases these operations may need to be combined.

Tenotomy of lateral rectus

When operating upon a case of divergent squint, it is desirable to leave the eyes convergent to the extent of 3–5 degrees. It is usually necessary to perform a free tenotomy

of the lateral rectus muscle first and a liberal resection of the medial rectus muscle, except in the case of a small intermittent deviation when tenotomy or recession of the lateral rectus alone may suffice.

Even after free tenotomy of the lateral rectus muscle, it is rare for the eye to show any gross subsequent defect in the power of abduction.

It should be noted that these remarks do not apply to cases of secondary divergent squint due to the surgical over-correction of convergent squint. Here more caution is required; a small resection of the medial rectus with or without a recession of the lateral rectus should be sufficient.

(3) Operations for vertical strabismus

Causation Vertical strabismus of any magnitude is invariably due to paralysis or paresis of one of the vertically acting muscles (superior and inferior rectus muscles and superior and inferior oblique muscles), and it is important first to find out which particular muscles are affected.

Muscle groups It must be remembered that there are four vertically acting muscles to each eye and only two horizontally acting muscles, and that the vertically acting muscles are divisible into "dextro" and "laevo" groups, according to whether their maximal vertical action is exerted when the eyes are in dextro-version or laevo-version.

When dealing with a case of paresis of one of the dextro-muscles it is usually desirable to confine the surgical treatment to that group of muscles, and not to interfere with the laevo-group, otherwise an incomitant result may occur.

Thus the possible alternatives in a case of right superior rectus palsy are: (a) advancement or shortening (resection) of the paralysed muscle (right superior rectus); (b) recession, marginal myotomy or tenotomy of the ipsolateral antagonist (right inferior rectus); (c) recession, marginal myotomy or tenotomy of the contralateral synergist (left inferior oblique); (d) resection or plication of the contralateral antagonist (left superior oblique).

General rule The second and third alternatives are those more usually employed. As a general rule, it is inadvisable to perform a complete or free tenotomy of a vertically acting rectus muscle, but this is not so in the case of an oblique muscle, the reason being that the vertical rectus muscles have a much stronger vertical action than the oblique muscles, and a free tenotomy is likely to cause an over-correction.

It should be remembered that an imbalance of the vertically-acting muscles which is accentuated by depression of the eyeballs is more distressing to the patient than one which is accentuated by elevation, owing to the fact that everyday life is concerned much more with looking downwards than it is with looking upwards. If a patient, although possessing binocular vision when looking straight ahead, sees double when elevating his eyes, the fact is less likely to cause inconvenience, than if he experiences diplopia when depressing his eyes (except in special circumstances). It is, therefore, wise when operating upon a depressor muscle of one eye to exercise great care not to leave the patient with a paresis of depression of that eye, such as might cause vertical diplopia on looking downwards.

(4) Tenotomy or partial myectomy of the inferior oblique muscle

Procedure

In this operation, instead of exposing the muscle by means of an incision through the conjunctiva, a curved incision is made through the skin along the lower orbital margin, the orbicularis oculi is split, the orbital septum incised and the orbital cavity exposed (Fig. 41). The inferior oblique muscle is then identified, and a portion of it resected (at least 10 millimetres) in order to prevent it re-attaching itself to the orbit. The operation performed in this way does not entirely remove the action of the muscle, owing to the fact that its attachment to the outer part of the floor of the orbit by means of a prolongation of Tenon's capsule remains intact. In cases in which there is only a slight degree of overaction of the inferior oblique, a partial tenotomy may be performed.

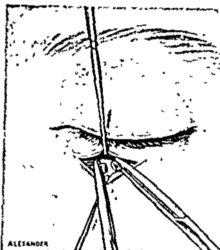


Fig. 41.—Inferior oblique myectomy, external route.

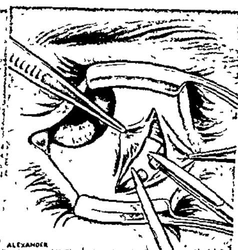


Fig. 42.—Inferior oblique myectomy, transconjunctival route. Exposure of muscle below the lateral rectus

Conjunctival route

The inferior oblique muscle may, however, be quite easily reached *via* the conjunctival route, by approaching it either where it lies adjacent to the lower margin of the external rectus (Fig. 42) or at its origin, through the lower conjunctival fornix.

(5) Operations for relative paralysis

Although cases of relative paralysis of the horizontally or vertically acting muscles due to local orbital injury causing a displacement of the visual axis should be treated along lines similar to those adopted in cases of muscle palsy due to a nerve lesion, there are certain differences to be observed.

Since there is no nerve lesion, the overaction of the contralateral synergist is usually slight in degree, so that a better result is usually obtained by actually shortening the relatively weak muscle (usually a superior or inferior rectus muscle) than by weakening the contralateral synergist.

Pre-operative investigation

Such cases require careful pre-operative investigation, and surgical treatment is usually required in two or more stages, depending upon the degree of deviation.

In cases of recent origin, when there is obvious bony displacement, restoration of the normal anatomy is a desirable, although not always possible, preliminary.

(6) Operations for latent strabismus (heterophoria)

In cases of heterophoria in which the tendency for the eyes to deviate is not fully compensated, and in which symptoms due to this fact occur and cannot be overcome by orthoptic treatment alone, operation is indicated in order to overcome the latent deviation. The principles involved are precisely the same as those for cases of manifest strabismus *Indications*

(7) Anaesthesia in operations for squint

It used to be thought that squint operations should be performed under local anaesthesia, so that a more accurate result could be obtained. There may be advantages in maintaining the patient's co-operation, and in preserving the normal tone of the ocular muscles, yet this is by no means essential and in all cases of strabismus in young children and in many cases of strabismus in adults, general anaesthesia is preferable. *General anaesthesia preferable*

(8) Post-operative care

After most operations for strabismus it is desirable to keep both eyes padded for a few days—in fact, until the patient is able to keep both his eyes open with comfort. It is undesirable in any case in which a "binocular result" is envisaged to keep only one eye covered up. After certain operations, such as tenotomy or recession of the horizontally-acting recti or myectomy of the inferior oblique, it is not necessary to cover either eye at all after operation.

Usually, it is not necessary for a patient to stay in hospital for more than 7–10 days after operation, and in certain cases 3–4 days only are sufficient.

11. RESULTS OF TREATMENT

With the exception of cases of complete, or almost complete, third cerebral nerve palsy, there are few cases of squint that are not amenable to cosmetic correction by means of operation, often to be performed in more than one stage, and in a large percentage of all cases of squint a functional cure is obtained with restoration of binocular single vision.

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SUBPHRENIC ABSCESS

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1. DEFINITION

314.] The subphrenic region is usually taken to refer to that part of the abdomen which is immediately below the diaphragm, and as abscesses in this area have a well-defined clinical picture they are considered as a single group. Not all these abscesses, however, are actually in contact with the diaphragm, so that it is convenient to classify as subphrenic all those abscesses which occur in the abdomen above the level of the transverse colon and mesocolon, with the exception of those which lie entirely within the organs which occupy this space.

The term "subphrenic abscess" was first used by Barlow in 1845, but Martinet in 1898 described the anatomy of the region from the point of view of suppuration, and Barnard in 1908, shortly before his death, gave what for long remained the classical description, illustrated by 78 examples from the London Hospital.

2. ANATOMY

Too much stress has perhaps been laid on the influence that the anatomical boundaries in this region have on the site of these abscesses, for, in every case of intraperitoneal abscess, part of the wall of the abscess is formed by inflammatory adhesions, and not by normal anatomical structures; extra-peritoneal abscesses, however, occur at sites where there is normally no potential space and are thus even less limited by anatomical boundaries.

3. AETIOLOGY AND INCIDENCE

Peritonitis

The great majority of subphrenic infections are part of either a localized or a generalized peritonitis, but it is only in a proportion of such infections in this area, probably less than half, that suppuration ensues and a subphrenic abscess forms. When such an abscess follows a *generalized peritonitis* there are likely to be other abscesses in the peritoneal cavity, and the subphrenic abscess may only be suspected when drainage of another abscess has failed to bring about improvement in the patient. Extraperitoneal subphrenic abscesses are more likely to be due to direct spread of infection from an adjacent organ, for example, the kidney, liver or pancreas, or from osteomyelitis of the spine.

Sex and age

Ochsner and DeBakey (1938) have analysed 3,608 cases from the literature, and the following figures are taken from their extensive review. The condition *is more common in males than females, in the ratio of about 2 to 1. It is most* often met with in middle life, due to the fact that the common causative lesions occur in adult life, but, though it is rare in childhood, *no age is exempt.* More than 75 per cent of these abscesses occur on the right side.

These authors found that 84 per cent of subphrenic abscesses were the result of an intra-abdominal suppurative lesion, and the following Table gives the relative incidence of the causative organs.

Organ	*Per cent*
Appendix	30·7
Stomach and duodenum	28·7
Liver and gall-bladder	12·8
Spleen	3·7
Kidney	2·9
Intestine	1·8
Female genitalia	1·4
Pancreas	1·2

Thus three out of every five subphrenic abscesses are the result of suppurative lesions of the appendix, or spread of infection from the stomach or duodenum; practically all of the last group are a complication of a peptic ulcer, though occasionally a subphrenic abscess occurs as a result of infection through a carcinoma of the stomach. The usual story is that there has been an acute perforation which has been repaired, but a localized peritonitis persists and after two or three weeks there is evidence of an abscess. Sometimes, however, there is no definite history of a sudden perforation but infection has spread through the base of the ulcer, or else there has been a slight leak which has become sealed off by adhesions. Whether the abscess follows acute appendicitis or a perforated ulcer, the subsequent development of a subphrenic abscess is due nearly always to delay in instituting treatment for the primary condition.

Trauma

Of the remaining cases 2·1 per cent were traumatic; these figures were collected before the second World War, when a considerable number of subphrenic abscesses occurred following injury to the abdominal viscera, particularly the stomach and colon, by gun shot or bomb fragments.

Spread from thorax

In only 2·4 per cent was it considered that spread had occurred from the thorax; even this is probably an exaggerated figure, for when the lesion follows a pneumococcal empyema it is very difficult to know whether it is the

result of a direct spread through the diaphragm, or whether it results from the localization of a metastatic peritonitis.

The infection was tuberculous in 0·9 per cent, and in such cases spread from a lesion of the vertebrae is the usual aetiology; similarly staphylococcal abscesses may occur in osteomyelitis of the spine. *Tuberculous infection*

In the remaining 11·4 per cent in the collected series the abscess was considered to be metastatic, or the cause was not found or was not recorded, or it was due to other causes not mentioned above.

With the increase in experience of the surgery of the upper part of the stomach and the abdominal part of the oesophagus, there has been an increase in the incidence of post-operative left-sided subphrenic abscesses as a result of infection from the line of anastomosis, and such an abscess must be borne in mind as a complication of these operations.

In view of the varied aetiology, there are no specific bacteria particularly associated with subphrenic abscesses.

4. CLINICAL PICTURE

In the great majority of cases, the presence of a subphrenic abscess is discovered when other sites of an abscess have been excluded; as a rule the patient does not complain of any local symptoms; pain at the site of the abscess or referred to the shoulder is an unusual feature; sometimes there is oedema of the chest wall over the abscess, and occasionally the abscess will point through an intercostal space or under the costal margin. *Absence of local symptoms*

(1) Symptoms and signs

A subphrenic abscess must be suspected in any patient who has had an infected lesion in the abdomen, and who shows evidence of continued suppuration, though the local lesion has been adequately treated. There is fever, anorexia, a leucocytosis, and, as a rule, loss in weight; it is surprising, however, how well some patients feel in spite of the presence of a large abscess in this region, while others have evidence of severe toxaemia with quite a small abscess; care is necessary because the administration of antibiotic agents may mask the symptoms and bring the temperature to normal although a collection of pus is present. As with pleural empyemas, very small abscesses may slowly resolve without drainage and others may be rendered relatively sterile by the use of chemotherapy, but the more usual course is for the degree of toxaemia to increase, and the patient goes downhill to a fatal termination. It occasionally happens that an abscess ruptures spontaneously, either through the skin or into the alimentary canal, or through the diaphragm and adherent lung into a bronchus, the contents being coughed up, but when this happens through the skin or into a bronchus, drainage is not as a rule adequate and further treatment is necessary. *Spontaneous rupture*

In some cases there is a pleural effusion on the same side, and this may progress to an empyema, a complication which occurred in 17 per cent of the collected cases referred to.

The physical signs are scanty; there may be tenderness below the costal margin in front, or just under the twelfth rib behind; some degree of impairment of respiratory movement of the lower ribs on the affected side may be noticed, as well as impaired percussion note and diminished breath sounds at *Physical signs*

the base of the lung; the presence of oedema of the chest wall over the abscess is a late sign and only occasionally found.

(2) Radiographic appearances

In suspected cases radiological examination is of great value; the diaphrag may be raised, and its movements will be diminished on the affected sid When the examination is made in the upright position a fluid level with som gas above it may be seen and this is most characteristic, but is found only in about one-third of the cases (Fig. 43); the presence of a pleural effusion as a complication will obscure the shadow of the diaphragm.

(3) Mode of onset

Subphrenic abscesses following acute suppurative lesions in the peritoneal cavity tend to occur between ten days and three weeks after the primary incident, but attention has been drawn to two variations, one in which the onset is quite sudden, and the patient develops a large abscess and severe toxaemia very quickly, and the other in which the onset is insidious, and the patient may be ambulatory and in fact may return home, only to come back to hospital some weeks later because his progress has been unsatisfactory o- because he has developed some complication of the abscess. With the use c chemotherapy there seems to be little doubt that this insidious type i becoming more frequent.

5. DIFFERENTIAL DIAGNOSIS

Suppurative pylephlebitis

Amoebic abscess

Actinomycosis

Empyema

Other suppurative lesions in the area may be confused with subphrenic abscess; on the right side they mainly affect the liver—suppurative pylephlebitis, actinomycosis, and amoebic abscess; in pylephlebitis there will be rigors, a rare feature of subphrenic abscess; when there is a history of dysentery the effect of emetine may be tried, while in the majority of actinomycotic cases the fungus can be found in the primary lesion; it should be remembered that in any of these three conditions the infection may spread outside the liver and thus cause a subphrenic abscess. It may be difficult to distinguish between an empyema and a subphrenic abscess, but skiagrams and aspiration of the chest will usually settle the diagnosis, though occasionally exploration may be necessary.

6. COMPLICATIONS

eural usion

yema

Bronchial fistula

Some of the complications have already been mentioned; it has already been noted that it is very rare for infections to spread downward from the thorax through the diaphragm; but spread in the reverse direction is the natural method of extension of a subphrenic abscess; thus a pleural effusion is a common complication, and is no doubt due to extension by way of the diaphragmatic lymphatics. Sometimes this effusion may progress to an empyema, which is the next complication in order of frequency, and which may be the result of a serous effusion becoming purulent, or may be caused by actual perforation of the diaphragm so that the cavities of the two abscesses communicate. There are cases, however, in which the lung becomes adherent to the diaphragm before this stage is reached, and thus when the perforation occurs it takes place into the lung, giving rise to a bronchial fistula; with a large abscess this catastrophe may occur so suddenly

that a debilitated patient may drown in the pus from his own abscess unless immediate postural treatment is instituted.

Other rare complications are pericarditis, mediastinal abscess, lung abscess, and general peritonitis; perforation into the alimentary canal is a little more frequent than perforation through the skin, the latter being more likely to follow abscesses which lie in contact with the anterior abdominal wall.

7. PROGNOSIS

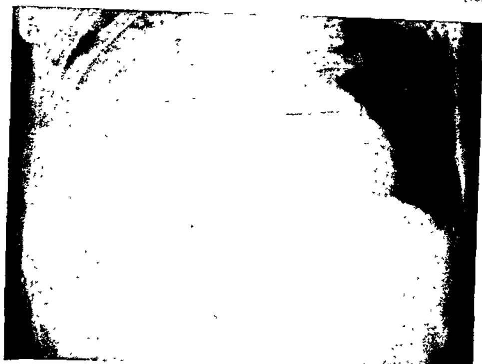
Subphrenic abscess is a serious condition; Ochsner and DeBakey found that in the recorded cases treated conservatively the mortality was almost 90 per cent. There is no doubt that in recent years, since surgeons have been more aware of its possibility, the danger has fallen considerably, and in those cases treated by extra-serous drainage the mortality rate was only 10·8 per cent. It is therefore imperative that abdominal surgeons should constantly bear it in mind, for early diagnosis and early drainage are the key to success in the treatment of this condition. *Mortality*

8. TREATMENT

In spite of the modern advances in therapy by antibiotic agents, treatment of subphrenic abscess consists in adequate drainage as soon as the diagnosis is established. Delay in drainage involves serious risk of those complications which may prove fatal. It is probable that with the aid of chemotherapeutic agents an increasing proportion of subphrenic infections resolve without suppuration, but as soon as there is any reason to suspect the presence of pus, active measures to confirm this must be undertaken. *Drainage*

(1) Diagnostic aspiration

This raises the question of diagnostic aspiration. Such a procedure has been condemned in view of the risk of infecting the pleural cavity, but apart from actual exploration it may be the only means of making certain of the diagnosis. Many of these patients are severely ill, and an open exploration which fails to drain an abscess may turn the scales heavily against the patient, whereas an attempted aspiration which fails to find pus is practically devoid of risk, and is most unlikely to infect the pleural cavity; on the other hand there is evidence that aspiration through a free pleural cavity does carry some risk of spreading infection to that space. Each case must therefore be considered on its merits; it is going too far to say that aspiration should never be attempted, but its use without very strong indications is to be deprecated. When the diagnosis and localization can be made by other methods there is no need for aspiration, and open drainage should be employed straight away; when the diagnosis is in doubt but the presence of pus is suspected, cautious aspiration may be attempted, but certain precautions are necessary; the first attempts at aspiration should be low down, starting below the level of the anatomical reflection of the pleura and the needle should be inserted higher up only if the area is dull to percussion. Such aspiration should be carried out only in an institution where facilities are available for immediate open operation should pus be found, as it is most important that, if the needle has traversed the pleural cavity and entered the abscess through the diaphragm, it should not be withdrawn, but should be left in position and fixed



(a)



(b)

FIG. 43.—Skiagrams of a right-sided suprahepatic subphrenic abscess containing gas and showing fluid levels. (a) Antero posterior, and (b) lateral view. Note the raised diaphragm and the pleural effusion Although this abscess is in front of the coronary ligament it is drained by the posterior route (*see* Fig. 46)

with strapping, until the abscess has been drained. In contradistinction to empyemas the pus in a subphrenic abscess is usually thin and will flow through a medium-sized aspirating needle.

(2) Methods of drainage

The method of drainage is most important; the risk of draining through a serous cavity, particularly the pleura, is considerable, for unless there are adhesions the lung will collapse and a total empyema will result. Extra-serous methods are therefore employed whenever possible. The method differs according to whether the abscess is anterior or posterior, and it must be pointed out that, for practical purposes, on the right side it is not the coronary ligament which forms the boundary line. On this side practically the whole of the dome of the diaphragm is in front of the coronary ligament, which is attached to the posterior aspect of the liver; this can easily be verified at a laparotomy, when it is possible to pass the hand from the front well over the dome of the diaphragm to the posterior aspect before it meets the obstruction caused by the coronary ligament. It therefore follows that any abscess which can be shown by skiagram to occupy the dome of the diaphragm must lie in front of the coronary ligament, in the right suprahepatic space (Fig. 43), yet abscesses in this position often present more marked physical signs posteriorly than in front and may be associated with an abscess in the subhepatic space; in fact, if the signs are more marked behind, these abscesses should be drained from the back, for this is in such cases the route by which the infection reached the space, and posterior drainage is more dependent, and can be done with less risk of opening the free peritoneal cavity; at the same time during the approach, the subhepatic space is passed, and if it contains pus, this can be drained by the same route; the writer thinks that in some cases drainage is unsatisfactory because of lack of appreciation of these facts; the story is that a skiagram shows pus under the right dome of the diaphragm, and drainage is carried out by the posterior approach; as the subhepatic pouch is reached pus may be found and the operator is led to believe that he has drained the main abscess, whereas in fact there is a further collection of pus in front of the coronary ligament, and it is necessary to explore further, to go past the bare area, and thus expose the right suprahepatic space where the pus lies. Only those abscesses which show physical signs of their presence in front should be drained anteriorly. *Route of infection*

(a) *Extra-serous drainage*

(i) *Posterior approach.*—The extra-serous posterior method of drainage, which is now employed for all subphrenic abscesses drained from behind, was first described by Nathan and Ochsner (1923), the approach being either below the twelfth rib or through the bed of this rib. General anaesthesia using nitrous oxide and oxygen is preferable to local anaesthesia, because infiltration of the tissues under the diaphragm is impossible without risk of spreading infection through the diaphragm by the injecting needle, and muscular relaxation is not required. The incision is made along or just below the line of the last rib, and if the rib is to be resected, the periosteum is incised, so that the rib is removed subperiosteally. A transverse incision (Figs. 44, 45) is then made through the bed of the rib, or through the muscles below it at the level of the transverse process of the first lumbar vertebra, thus ensuring *Anaesthesia* *Site of incision*

that it is below the pleural reflection, and if the subcostal vessels and nerve are to be cut by this incision it is better to under-run them with catgut first. This transverse incision provides access into the extraperitoneal tissues immediately below the lateral arcuate ligament, and the finger can then be

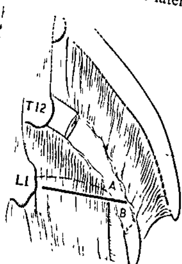


FIG. 44.—Sagittal section through the upper abdomen 2 inches to the right of the midline. The positions of suprahepatic and infrahepatic intraperitoneal abscesses are shown, they are separated by the coronary ligament of the liver with the bare area between its folds. The abscesses are limited in front by inflammatory adhesions. Abscesses in these situations may communicate lateral to the free edge of the coronary ligament. The dotted line shows the route of drainage; the twelfth rib may have been resected more laterally, but at this point the quadratus lumborum muscle is incised, thus avoiding injury to the pleura.

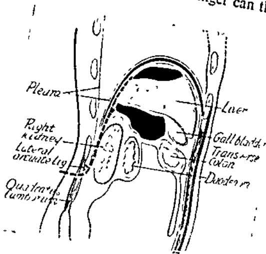


FIG 45.—Diagram showing position of incision through the bed of the twelfth rib and quadratus lumborum muscle to ensure avoiding injury to the pleura on the right side. It is advisable to under-run the subcostal vessels and nerve at A and B. The line between A and the transverse process of L.I represents the position of the external arcuate ligament.

passed upwards below the diaphragm, displacing the upper pole of the kidney forwards; as the abscess is approached, induration will be felt, and a little force may be required to open the actual cavity. It is often helpful at this stage to use an aspirating needle in order to localize the pus exactly, as when there is much induration the precise outline of adjacent solid organs—the liver and kidney on the right, and the spleen and kidney on the left—may be difficult to determine. If radiological examination has shown evidence of pus under the dome of the diaphragm on the right side, the operator must not be content with drainage of the subhepatic space alone, even if pus has been found there, but must proceed, separating the bare area of the liver from the diaphragm, until the pus lying above and in front of the coronary ligament is also drained.

(ii) *Anterior approach.*—An abscess which presents physical signs in front should be drained by an incision through the abdominal wall parallel to and just below the costal margin, unless it is actually pointing through an intercostal space; if during the approach the free peritoneal cavity is opened, the omentum should be drawn up and sutured to the margins of the incision in the peritoneum before the abscess is opened, and pus should be evacuated by a suction tube in order to avoid spilling on to the wound.

(iii) *General rules.*—For drainage it is better to use a wide-bore soft tube rather than corrugated rubber, for it is most important that for the first few days drainage should be quite free (Fig. 46). The rules which apply to the length of time of drainage are similar to those established for empyemas; drainage must be maintained until the cavity is obliterated, and it may only be possible to determine this point by radiography after the injection of opaque oil into the cavity, as a rule drainage is required for two to three weeks, and if a sinus persists after this time a cause must be sought.



FIG. 46.—Skiagram showing drainage after resection of twelfth rib (same case as Fig 42)

(*b*) *Transpleural drainage*

If, when the surgeon has opened the thorax under the impression that he is dealing with an empyema, he finds that the pleural cavity is uninfected, and that the pus is below the diaphragm, it is better that he should close up this wound altogether, and make a fresh incision as already described, rather than run the risks attached to drainage of a subphrenic abscess through a free pleura, for the method formerly recommended of suturing the two layers of pleura together before incision of the diaphragm does not eliminate these risks; if, however, it is found that the pleural space in this area is already obliterated by adhesions, there is no objection to incision of the diaphragm and to drainage by this route.

(3) Complications

The treatment of the common complications calls for no special comment, an abscess which has ruptured spontaneously through the skin is unlikely to drain adequately and the opening will require enlarging if a persistent sinus is to be avoided. If the abscess ruptures into a bronchus, again drainage will probably prove unsatisfactory, and if all symptoms do not clear up in a few days, the abscess should be drained by the appropriate route, after which the bronchial fistula will almost certainly close, but if such drainage is not provided early the fistula may persist and lead to chronic suppuration in the lung.

that it is below the pleural reflection, and if the subcostal vessels and nerve are to be cut by this incision it is better to under-run them with catgut first. This transverse incision provides access into the extraperitoneal tissues immediately below the lateral arcuate ligament, and the finger can then be

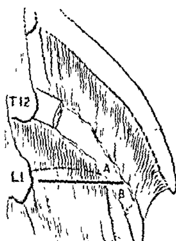


FIG 44.—Sagittal section through the upper abdomen 2 inches to the right of the midline. The positions of suprahepatic and infrahepatic intraperitoneal abscesses are shown; they are separated by the coronary ligament of the liver with the bare area between its folds. The abscesses are limited in front by inflammatory adhesions. Abscesses in these situations may communicate lateral to the free edge of the coronary ligament. The dotted line shows the route of drainage, the twelfth rib may have been resected more laterally, but at this point the quadratus lumborum muscle is incised, thus avoiding injury to the pleura.

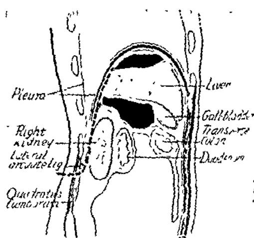


FIG. 45.—Diagram showing position of incision through the bed of the twelfth rib and quadratus lumborum muscle to ensure avoiding injury to the pleura on the right side. It is advisable to under-run the subcostal vessels and nerve at A and B. The line between A and the transverse process of L.1 represents the position of the external arcuate ligament.

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[References to other titles are given under Subphrenic Abscess in the Index Volume]

SUPRASPINATUS LESIONS

By R. GUY PULVERTAFT, F.R.C.S.

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1. ANATOMY OF SHOULDER FUNCTION

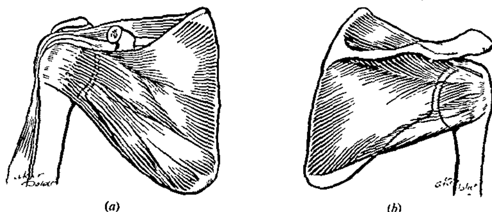
315.] The shoulder joint is covered by the deltoid muscle, a triangular mass arising from the lateral third of the clavicle, the acromion and the spine of the scapula The muscle converges to its insertion into the deltoid tuberosity of the humerus.

Beneath the deltoid muscle lies the subacromial bursa which separates the muscle, acromion and coraco-acromial ligament from the deep muscles and tendons merging with the joint capsule.

The deep muscles, four in number, arise from the scapula and are inserted as a flattened and continuous band into the anatomical neck of the humerus; the main attachment of subscapularis muscle goes to the lesser tuberosity, and the supraspinatus, infraspinatus and teres minor muscles go to the greater tuberosity (Fig. 47). The adjacent borders of these tendinous insertions cannot be readily distinguished and Codman (1934a) termed the combined structures the musculo-tendinous cuff. *Deep muscles*

Action of the musculo-tendinous cuff

Numerous accounts have been given of the *function of these muscles*. In addition to their individual actions, they combine to form a sling which stabilizes the humeral head during the action of abduction. Codman (1934b) pointed out that the supraspinatus muscle, which is virtually the central



(*a*) (*b*)

FIG. 47.—Muscles forming the musculo-tendinous cuff, (*a*) anterior aspect, (*b*) posterior aspect. (*After Toldt*)

muscle of the group, can itself act as a weak abductor even if the deltoid is paralysed.

Rupture of the supraspinatus tendon destroys the function of this muscle and also *permits the central part of the cuff to gape (Jones, 1944)*, thus disturbing the sling effect of the combined structure. Gleno-humeral abduction is weakened or completely lost, depending upon the extent of the tear.

2. SURGICAL APPROACHES

(1) Anterior approach (Codman's bursal incision)

A 2-inch incision is made downwards from the acromio-clavicular joint and the deltoid *fibres are split* exposing the subacromial bursa (Figs. 48 and 49). The bursal roof is opened and, by rotating the humeral head, the complete floor can be examined. The branches of the axillary nerve to the anterior part of the deltoid muscle are endangered if the incision is carried too low.

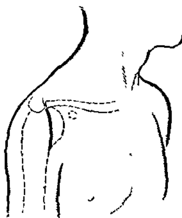


FIG 48.—Codman's bursal incision.

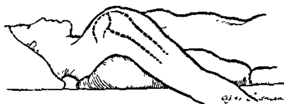


FIG. 49.—Position of patient advised by Codman. (*After Codman*)

The exposure is sufficient for exploration and removal of calcified deposits, and for the suture of a recent supraspinatus rupture, but it is inadequate for repair of old or complete cuff ruptures.

(2) Anterior approach (shoulder-strap incision of Henry)

The incision follows the delto-pectoral groove downwards to the deltoid insertion and extends upwards and posteriorly to the level of the scapular spine (Fig. 50). The deltoid cowl is turned outwards by removing its attachment to the outer third of the clavicle. If necessary the deltoid muscle may be safely reflected still further by detaching its origin from the edge of the acromion.

The anterior and lateral aspects of the joint may thus be exposed and full access established.

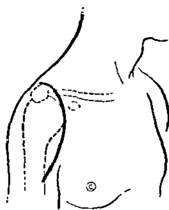


Fig. 50.—Henry's incision

(3) Superior or sabre-cut incision

Incision

The most recent modification of this incision has been developed by McLaughlin (1944a) who combines Codman's sabre-cut incision and Kocher's posterior approach.

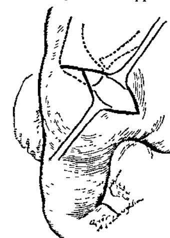


Fig 51.—McLaughlin's incision

The skin incision follows the shoulder-strap line and is placed just lateral to the acromio-clavicular joint, extending from the posterior margin of the acromion to a point 2 inches in front of its anterior margin (Fig. 51). The anterior part of the incision is deepened and the deltoid fibres are split to expose the bursal roof and the coraco-acromial ligament; these structures are incised and the musculo-tendinous cuff is exposed. McLaughlin points out that minor procedures can be carried out through this limited incision, but if further exposure is required, the acromion is split and a wide view sufficient for most procedures obtained. In closing the wound the detached fragments of acromion may either be removed or preserved.

3. RUPTURE OF THE SUPRASPINATUS TENDON

Degeneration of tendon

Repeated investigations into necropsy and cadaver material have shown that the supraspinatus tendon is prone to undergo degenerative changes with increasing years. In the series of Wilson and Duff (1943) the incidence of complete rupture among 108 unselected bodies over the age of 30 was 22 per cent, the average age being 65 years. The incidence of partial rupture among 74 unselected bodies over the age of 30 was 20 per cent, with the average age of 62 years.

It is probable that degenerative changes occur in tendinous tissue in general with increase in age. Where constant strain is an added factor rupture of the degenerated tendon is not uncommon.

It is significant that in a normal bone-muscle-tendon-bone system the weakest link is the bone; experimental work has shown that rupture with

increasing tension never occurs in the tendon tissue (McMaster, 1933)

Microscopical changes

Microscopical examination of the material investigated by Wilson and Duf showed degenerative changes in the supraspinatus tendon, characterized by alteration in tendon structure and staining qualities. It is reasonable to conclude that where clinical rupture occurs it has been preceded by the degenerative changes seen with increasing age, especially in persons engaged in heavy manual work.

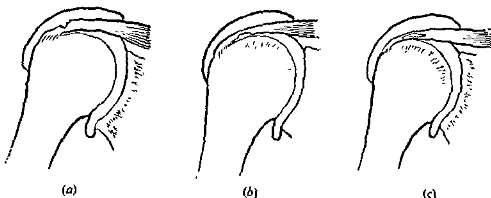


Fig. 52.—Partial rupture of supraspinatus tendon; (*a*) bursal type, (*b*) rim rent type, (*c*) central type.

Partial rupture

Partial rupture may involve only the tendon fibres on the bursal side of the tendon, only those near the joint cavity (rim rent) or only the central fibres without tearing either surface of the tendon (Fig. 52). In these cases no communication will be established between the shoulder joint and the subacromial bursa.

Complete rupture

Complete rupture involving the whole of the tendon and adjacent layers permits communication between joint and bursal cavities (Fig. 53) The rupture may remain isolated to the supraspinatus tendon but may also involve the subscapularis and infraspinatus tendons.

Cause

The injury is usually caused by a stumble or fall while the arm is abducted violently in an effort to break the fall, or by forcible abduction of the arm against an unyielding resistance.

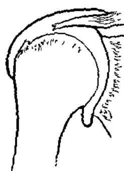


Fig. 53.—Complete rupture of supraspinatus tendon

(1) Clinical features

Pain

The patient may be conscious of a sudden snap in the shoulder. There is inability to move the arm and pain radiating from the shoulder to the mid arm is experienced. The pain characteristically becomes worse as the hours pass until it becomes intense and renders sleep impossible.

The shoulder assumes the shrugged position on attempting to abduct the limb. The humero-scapular rhythm is reversed; any abduction that may occur is produced by movement of the scapula on the chest wall, The passive range is complete, provided that the spasm due to pain is overcome, either by gentle handling or by the injection of local anaesthetic. Passive abduction may be obtained by bending forwards and sideways at the hips and allowing gravity

to abduct the arm; once the tender supraspinatus attachment has passed under the edge of the acromion process or coraco-acromial ligament, the patient will offer no further resistance to passive abduction.

It is not always easy to distinguish between complete and partial ruptures. Full voluntary movements are restored to the patient with partial rupture when pain is completely abolished by adequate infiltration with local anaesthetic. Patients with extensive complete ruptures lose all voluntary abduction: if the arm is raised from the side, it will drop immediately once it is released.

(2) Radiographic examination

Skiagrams reveal no abnormality in the early stage. As time passes, the humeral head rides high in the glenoid cavity and changes in the density and contour of the greater tuberosity may become apparent. Contrast media (6 cubic centimetres of 35 per cent Diodrast with 1 cubic centimetre of 1 per cent procaine hydrochloride) injected into the shoulder joint has been used to determine whether a communication has occurred between the joint and bursal space (Lindblom, 1939). *Contrast media*

(3) Treatment

(a) Recent injuries

For practical purposes three groups may be considered: (i) reasonably certain complete ruptures; (ii) doubtful cases; and (iii) reasonably certain incomplete ruptures.

(i) *Reasonably certain complete ruptures.*—In these cases exploration is advisable. It is usually possible to effect a satisfactory repair by suturing the tendon to bone by means of small drill holes in the greater tuberosity

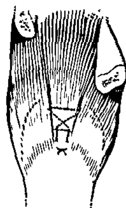
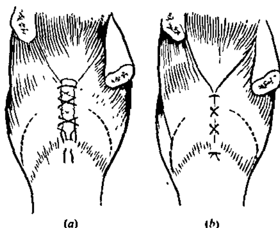


FIG. 54.—Standard repair of supraspinatus rupture



(a) (b)

FIG. 55.—(a) McLaughlin's repair of supraspinatus rupture; (b) operation completed.

(Fig. 54). McLaughlin's (1944a) method of lacing together the opposing lateral edges of the defect is a valuable alternative method (Fig. 55).

The after-treatment consists of splintage in 90 degrees abduction in the scapular plane (25 degrees forward inclination from the coronal plane) for *After-treatment*

approximately 4–6 weeks until the patient can voluntarily raise his limb fr[om] the splint.

Exploration

(ii) *Doubtful cases.*—It is difficult to give positive advice on the treatment [of] those in this group. Generally speaking, it is wiser to explore rather than w[ait] to observe the result of conservative treatment. Exploration through a sm[all] incision is not harmful, but with delay a complete rupture presents increasi[ng] difficulty in operative repair.

Exercises

(iii) *Reasonably certain incomplete ruptures.*—Recent incomplete lesions a[re] best treated by one or more injections of local anaesthetic followed [by] physiotherapy. Unremitting treatment, including the patient's own gravit[y] assisted exercises, is essential, and usually leads to restoration of function [in] 6–8 weeks.

(*b*) *Old injuries*

For neglected cases or for those which were originally thought to be incom[-] plete lesions and have received conservative treatment without recovery, operative treatment is justifiable if the patient's general condition and person[al] needs justify interference. A full exposure should b[e] made and McLaughlin's repair technique employe[d] (Fig. 56). Cases of long duration are often com[-] plicated by capsular adhesions and passiv[e] mobility must be restored by manipulation unde[r] anaesthesia before operative repair is undertaken.

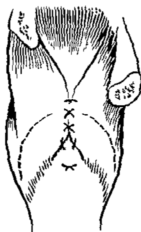


Fig 56 — McLaughlin's repair of supraspinatus rupture (Method employed in old injuries when gap cannot be fully closed.)

Secondary capsular adhesions

Secondary capsular adhesions can be the cause of marked disability in patients with old ruptures, and considerable improvement in function may be obtained by manipulation followed by intensive physiotherapy. Pain and discomfort are experienced after manipulation of the shoulder joint, making it essential to admit the patient to hospital for 5–7 days for effective after-treatment.

Arthrodesis

In the occasional case with severe persistent disability due to extensive complete rupture, the most practical measure to improve function may be arthrodesis of the shoulder joint.

4. CALCIFICATION OF THE SUPRASPINATUS TENDON

Incidence

Calcium deposits in the tendons of the musculo-tendinous cuff were first noticed by Painter and Codman in 1905 (Painter, 1907), and complete relief was obtained by operative removal. In 1941, Bosworth investigated 6,061 apparently normal shoulders in the course of life assurance examinations and found radiological evidence of calcium in 2·7 per cent of the whole group. He concluded that the deposits, which showed their highest incidence between the ages of 40 and 50 years, were most commonly found in those persons whose work required constant prolonged abduction of the arm. He pointed out that the condition is usually silent until injury initiates symptoms, but the syndrome may arise without apparent cause.

It is uncertain why calcium deposits form, but the explanation can probably be found in local necrosis following degenerative changes, with secondary deposit of calcium salts. *Cause*

The deposits appear in the tendon tissue, most commonly that of the supraspinatus, and gradually, or suddenly as the results of trauma, work through to the subacromial bursa. In acute lesions the material is usually fluid, but in chronic cases inspissation is present.

(1) Clinical features

(a) *Acute*

Acute symptoms may develop after a single strain, a period of overwork or for no apparent reason. There is complete inability to use the arm and intense burning pain is experienced. This pain is centred around the bursal region and radiates to the deltoid insertion and occasionally to the cervical part of the trapezius muscle. *Pain*

There is acute tenderness over the deposit, and attempts to move the shoulder are resented.

(b) *Chronic*

The chronic condition is heralded by a gradual onset of discomfort around the shoulder, with pain of a rheumatic nature radiating in the same manner. The patient finds it impossible to find a comfortable position for the arm and sleep is disturbed.

(2) Radiographic examination

Skiagrams should be taken in external and internal rotation and may show either a hazy or well defined shadow (Fig. 57).



FIG. 57.—Calcification in supraspinatus tendon (subsequently treated by operative removal of tooth-paste-like material.

(3) Treatment

(a) *Acute stage*

A fair proportion of acute lesions clear up by simple rest in a sling for 10–14 days. Those that are resistant may be treated either by aspiration of *Aspiration*

the fluid material using two wide-bore needles (Patterson and Darrach, 1937) or by operative removal using Codman's bursal incision.

McLaughlin (1944b), basing his conclusions upon the study of 1,500 cases of calcified deposits, advises aspiration followed by exercises in the majority of acute cases, and reserves operative removal for obstinate cases, or those in which the deposits are multiple.

(*b*) *Subacute stage*

The subacute condition can often be relieved by Novocain injections and intensive physiotherapy, including gravity-assisted exercises.

(*c*) *Chronic stage*

The chronic state is usually associated with thickening of the cuff and bursal walls, and the symptoms are mainly due to impingement of the tender thickening against the edge of the acromion process on abduction.

Conservative treatment in the form of ultra-short-wave therapy and pulley exercises may bring relief in time, but operative treatment offers the more certain and the more rapid relief.

Excision of acromion process

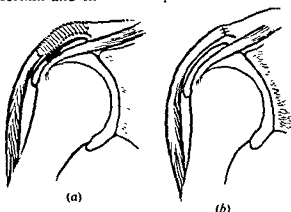


FIG. 58.—(*a*) Impingement of thickened cuff against acromion process. (*b*) relief of impingement by excision of the acromion process.

Excision of the acromion process is effective and if satisfactorily performed leaves no ill-effects. It should not be employed unless full passive range is present. Chronic cases may be complicated by capsular adhesions and full range should be restored by manipulation under anaesthesia and by exercises before operation. The sabre-cut incision is employed and the complete acromion process removed, including that part articulating with the clavicle (Fig. 58). The deltoid muscle is securely sutured to the cut surface of the acromion base and reflected periosteum. The limb is rested over a large axillary pad for 14 days before gentle gravity-assisted exercises are commenced (Watson-Jones, 1943; Armstrong, 1947).

5. ADHESIVE CAPSULITIS

The aetiology of this curious condition is not fully understood and it has been given a variety of names—periarthritis, subacromial bursitis, tendinitis, adhesive capsulitis and "frozen" shoulder. The term selected has at least the virtue of descriptive pathology, provided it is understood that inflammation in its strict sense is not intended.

Codman (1934c) stated that he found it a condition "difficult to define, difficult to treat and difficult to explain from the point of view of pathology". He explored a number of cases and found that all showed congestion over the supraspinatus tendon on the base of the bursa with associated adhesions, and he regarded the pathology as a tendinitis of the musculo-tendinous cuff. The most interesting contribution in recent years is that of Lippmann (1944).

SURGICAL TECHNIQUE

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1. THE VALUE OF SURGICAL TECHNIQUE

316] Judgement and technique are the essence of the artistry of surgery and reflect the individuality of the surgeon. Expert technique is not only an aesthetic accomplishment, but contributes in no small degree to the rapid healing of the parts and a calm restitution after operation.

Modern surgical technique values precision and delicacy above speed, and insists that the latter should be attained by careful planning of the operative stages and by the elimination of unnecessary movements. Speed derived from roughness, neglect of essential stages, careless technique and clock-watching, is a pre-Listerian relic and makes a doubtful contribution to the welfare of the patient. Indeed, it may not infrequently react to his detriment.

Primary healing

Uncomplicated convalescence is associated with the primary healing of all operative wounds. The rapid formation and unimpeded maturation of fibroblasts is the biological basis of primary healing. In terms of practical surgery, the precise apposition of healthy wound edges is indispensable.

Healthy wound edges depend on the quality and quantity of blood available to them during the healing phase. The quality of the blood is determined by the constitutional state of the patient. The quantity of circulating blood is markedly diminished by inflammatory oedema (arising from trauma or infection), and by tension.

Surgical technique is therefore directed to the prevention of infection, the avoidance of trauma, and the elimination of tension.

2. PRE-OPERATIVE MANAGEMENT

Despite the great boon of modern anaesthesia and the miracle of resuscitation in shock, the surgeon should ensure that his patient meets the ordeal of operation with a nervous, physical and physiological reserve best calculated to ensure success. To this end, sedation and the restoration of deficiencies in haemoglobin, vitamins, and glucose will pay big dividends. In modern surgery, no patient should face a deliberate major operation unless a positive *nitrogen balance exists in conjunction with adequate nutritional reserves.* Further, it is of great importance to continue this state of affairs into the post-operative period. *Restoration of deficiencies*

While the measures mentioned above are widely practised today, less care *is devoted by many surgeons to the preparation of tubal structures* (gut, bronchial tree, urinary adnexa) for operative intervention. This is to be deplored because the decompression and detoxication of these structures is of the greatest importance in primary healing. Tension should be avoided, and contents in a condition of stasis and infection must be purified by drainage and chemotherapy. The success of pre-operative decompression and detoxication (by sulphonamide compounds) of the intestinal and urinary tracts, and of the bronchial tree (by antibiotic insufflation), are among the great advances of modern surgical practice. *Decompression and detoxication of tubal structures*

3. OPERATIVE MANAGEMENT

The prevention of infection at operation depends on (1) organization in the operation theatre; (2) chemotherapy, systemic and local; (3) sterilization of the skin; and (4) surgical technique.

(1) Organization in the operation theatre

Organization in the operation theatre is designed to prevent contamination of the wound. The majority of modern theatres enjoy a very high standard in this regard—an accomplishment too often taken for granted by the surgeon himself. *Contamination*

Organisms derived from the air and the adjacent skin, from operating paraphernalia (gloves, instruments and sutures) and from other materials such as plaster casts and blankets, are the common causes of trouble.

The proportion of pathogenic organisms in the air is greatly increased, first, by exhalations from the respiratory tract of staff and onlookers in talking, coughing and sneezing, and, secondly, by the movement of non-sterile fomites, equipment or personnel.

In some modern hospitals ultra-violet irradiation is employed to ensure sterility of the air over the open wound. This innovation will not be available to the majority *of surgeons and they must compensate by strict attention to* other details. *Ultra-violet irradiation*

The knowledge that theatre routine in modern hospitals is thoroughly dependable should not permit of laxity on the part of the surgeon, and it behoves him to be vigilant in maintaining an impeccable standard. It is worthy of the greatest emphasis, however, that the earnest endeavours of the staff in maintaining a high degree of asept c preparation cannot compensate for surgical ignorance or the uncouth manipulation of tissues by a rough operator. *Impeccable standard*

In the last analysis, the skill and technical delicacy of the surgeon make a decisive contribution to healing *per primam.*

(2) Chemotherapy, systemic and local

The heritage of Lord Lister has burgeoned in these modern days. He would be a foolish surgeon indeed who did not keep pace with the development of chemotherapy. Pre-operative saturation of the offending site (bowel, bronchus or discharging sinus) and of the patient's blood stream with appropriate antiseptics or antibiotics is imperative when extrinsic or intrinsic contamination of the operation wound is possible or probable.

Gram-negative infection

The hazards of streptococcal infection have now been dispelled with adequate pre-operative preparation. There remains, however, the menace of infection by Gram-negative organisms, and to what degree streptomycin will dissipate this danger has yet to be revealed. Acridine derivatives (Monacrine) have some virtue in this regard, but only at the expense of considerable wound reaction. Their use must accordingly be restricted when the exudation of lymph occurs, and recourse must then be had to some more bland irrigant

It is worthy of record that penicillin enjoys a symbiosis with sulphonamide and acridine derivatives. Whether streptomycin will so react has yet to be confirmed.

Romansky preparation of penicillin

Pre-operative antibiotic saturation is now an established procedure by intermittent injection or by depot dosage (the Romansky preparation of penicillin in bees-wax and oil).

Infected cavities

Avascular tissues

Many surgeons believe that wounds containing foreign bodies (bone-plates, wires, or even non-absorbable sutures), or those which have endured excessive manipulation, should be sprinkled with appropriate antiseptics or antibiotics before closure. This also applies to infected cavities in the peritoneum (where penicillin, 100,000 units, with a sulphonamide, 3–5 grammes, should be used), or bone and abscess cavities (where acridine powder is of considerable value). Owing to their low resistance to infection relatively avascular tissues (fat, cartilage, tendon and bone) may also be safeguarded by such applications.

It is essential in modern surgery to make very full use of these important and indispensable contributions

(3) Sterilization of the skin

Sterilization of the skin should be vigorous, but not excessive, and less chemical than mechanical.

Secretions from sebaceous and sweat follicles

It is as yet not possible to free the skin completely from bacterial contamina- [illegible] that the [illegible] skin [illegible] en surface before and during the operation, and that these secretions contain bacteria.

Procedure

Modern surgeons have established rituals of varying complexity to cleanse the skin, but the essential features of this procedure are as follows.

(i) *Shaving of hair-bearing skin.*—The hair-bearing skin is shaved and it is of interest that many plastic surgeons do not cut the temple hair short in performing face-lift procedures, nor do they cut eyebrows or eyelashes when

performing plastic operations in that region. Hair so retained in the operation field is cleansed thoroughly with ether and rectified spirit. *Plastic surgery method*

(ii) *Soap and water cleansing.*—The skin is thoroughly but not excessively cleansed with soft soap and water. The bactericidal action of soap and water and its relatively innocuous action on the skin is not sufficiently appreciated. It presents a readily available method of skin cleansing which is cheap and efficient. Open wounds may be similarly cleansed to rid them of dirt and debris. Special care should be taken to clean creases and skin dimples, especially on the obese, who are very liable to intertrigo. *Bactericidal action*

(iii) *Covering of prepared area.*—The skin is covered with a freshly laundered garment. It is no longer necessary to expend large quantities of sterile linen on the covering of a skin surface which is to be the site of operation.

(iv) *Final cleansing of skin.*—The final pre-operative toilet of the skin is performed in the operation theatre. Most modern methods are efficient in this regard. A very popular and apparently reliable combination of a detergent, followed by the use of a rectified spirit in three alternating applications, is readily applicable to most operation sites. Where contaminating vents or fistulae exist close to the operation field they should be sealed off with a sterile pad fixed in place with sterile gauze and collodion or Mastisol, and the adjacent sterile towels sutured in position before making the incision. *Contaminating vents or fistulae*

(4) Surgical technique

Surgical technique represents the individual contribution of the surgeon to the prevention of contamination. A healthy wound is resistant to bacterial infection. The unhealthy traumatized wound is a favourable nidus for the incidence of sepsis.

Unnecessary trauma must be avoided: this is the hall-mark of good surgery. All unnecessary movement must be eliminated: this is the essence of speed.

(*a*) *The incision*

All incisions should be planned, adequate, and neatly executed.

(i) *Marking the incision.*—Wounds associated with plastic procedures, excision of superficial malignant lesions, wounds with irregular outlines, and *wounds in unusual sites where the cosmetic result is of great importance*, should be marked with a pen, using skin ink (2 per cent aqueous solution of gentian violet) (Fig 59). It is almost superfluous to add that the marking should follow, and not precede, the skin sterilization.

Wounds with vertical edges are easy to appose during closure; those with ragged or bevelled edges are correspondingly difficult.

(ii) *The incision*—Very short incisions, such as the excision of a mole on the face, can readily be made by stabbing the skin with a size 15 blade (Fig. 60). In this way overcarrying of the incision is avoided. *Making short incisions*

Long incisions should be first marked with the back of the knife and this line of incision cross-marked with scratches to indicate, during closure, those segments of the skin which must be accurately apposed *Making long incisions*

The handle of the knife is held in the palm, the index finger extending along the back of the blade to steady the instrument. The blade is plunged almost vertically into the skin, the index finger acting as a guard to prevent excessive penetration. The knife is tilted to an angle of 45 degrees to m
and brought to the vertical to complete it (Fig. 61).



FIG 59 —Incision marked with gentian violet ink in operation to raise abdominal tube pedicle.



FIG. 60 —"Stabbing" a short wound with a short blade in operation for stage removal of a facial naevus from a baby.

Incisions along natural creases and along the skin lines heal with less scarring than incisions across these lines (Fig. 62). The skin lines are best indicated by the direction of the lanugo hairs, which should be studied with a lens if necessary. When incisions cross these skin lines keloid scars are to be anticipated and special precautions should be taken in the post-operative phase to ensure a pleasing result. *Incisions along the lines of skin tension*

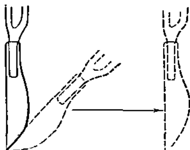


FIG 61.—Making a long incision. The knife point is entered at the perpendicular, the incision is made with the knife blade at 45 degrees and completed with the blade at the perpendicular.

FIG. 62.—Langer's lines (*Brit. J Su*

(iii) *The approach.*—In planning the approach, the exposure of the lesion to be dealt with should determine the site of the skin incision. Today a wide variety of incisions is available to the surgeon (such as the thoraco-abdominal, the transverse abdominal incision, and double transverse incisions in the neck), and have rendered possible the achievement of an indispensable to good surgery—adequate exposure.

Meddling

(iv) *Other considerations.*—It is the unfortunate habit of some surgeons, when not clear regarding the next move, to wipe or stroke the wound. Such movements are not progressive in so far as the completion of the operation is concerned. If such surgical barriers present themselves it is preferable to rinse the gloved hands, a movement which enhances rather than deters the process of healing.

Drying

In operations on delicate tissues (such as endothelial structures), it is imperative to keep the wound continuously moistened with isotonic saline, or citrate, solution. Drying of such structures invariably results in adhesions.

Fixed retractors

Considerable variety of opinion exists among surgeons as to whether the use of fixed retractors (employing the Hegar, Devine or similar abdominal retractor) is to be recommended The argument that the employment of these retractors increases the possibility of wound infection and post-operative chest complications is not proven, and the choice must be left to the individual surgeon One advantage of fixed retractors is that the wound edges may be covered with side towels or moist sponges, which are then held in place by the retractor. This manoeuvre contributes greatly to the prevention of wound contamination.

Lighted retractors

Exposure of the les on is improved in the deeper wound by the use of lighted retractors. Because the light must be restricted to the tip of the retractor those materials which may reflect even a small amount of light are unsuitable and metal retractors with a terminal light-source are still most approved in practice

(v) *The use of side towels.*—The use of fixed retractors renders possible the universal application of side towels to cover the edges of the wound. Many surgeons do not regard these as necessary. However, when non-absorbable sutures are employed, when manipulation of the skin edges is likely during operation, when septic or contaminating discharges may come into contact with the edges of the wound, when much handling of structures under the wound will be necessary, and when a recent wound has been re-opened, side towels are advisable. They are not necessary in those operations in which exposure is such that the operation on the underlying structures can be undertaken by what is virtually "no-touch" technique.

Chemotherapy

(vi) *Opening into septic cavities.*—When an abscess cavity or other septic cavity (for example, the colon) is to be opened, it is important to ensure that the patient has been adequately prepared by chemotherapy to prevent the spread of infection.

Prevention of contamination

The use of chemotherapy does not excuse the surgeon from the exercise of great care at the time of operation to prevent contamination of adjacent structures. The wound edges should therefore be protected, sponges should be packed about the area in which it is proposed to open the cavity and a sucker should be in readiness to absorb any contaminating discharge. The

first opening should be small in order that the escape of discharges can be controlled, and only when the efflux has diminished in quantity should the opening be enlarged.

All manoeuvres should be completed before the sponges are disturbed or changed. Before proceeding to any further steps in the operation the surgeon should change his gloves after rearranging the protecting swabs and sponges to his own satisfaction.

The use of local chemotherapeutic agents is strongly to be advised in such cases.

(*b*) *Haemostasis*

Haemostasis must be perfect, yet attained by atraumatic methods. It is preferable and conducive to the orderly conduct of the operation to effect haemostasis in each layer as it is incised and exposed.

(i) *Use of swabs and sponges.*—The removal of blood from the wound is best accomplished by the use of a sucker, by swabs, or by the use of sponges. Sponges are very commonly used for packing abdominal viscera out of the operation field.

The odium of having left a swab or sponge in the wound cannot be lightly set aside, quite apart from its medico-legal aspects. It is the responsibility of the surgeon to know how many swabs or sponges are being employed at the operation, to announce to his assistants when sponges or swabs are inserted into the wound and left *in situ* and, finally, to count the sponges himself at the conclusion of the operation (or after the peritoneum has been closed in abdominal cases).

The pronouncement of the surgeon regarding the insertion of sponges and swabs may be recorded on a blackboard by a theatre assistant, or the sponges themselves may carry long tapes with marked metal discs attached. These precautions enhance the security of the surgeon against mischance, but the important feature remains, that the surgeon himself should check the sponges and swabs at the termination of the essential part of his operation.

(ii) *Forcipressure and ligature*—It is easy to assess the quality and delicacy of the work of a surgeon when one views the size of his instruments. In routine work it is rarely necessary to use haemostatic forceps heavier than the Halsted (6 inch) forceps (Fig. 63). The small bite so taken involves more of the bleeding point and less of the adjacent tissues than when caught with heavier forceps.

In using fine forceps to secure bleeding points it is important to have a clear view of the bleeding vessel and to present a firm base against which to secure the vessel. One method of achieving this is shown in Fig. 64. By this means the amount of tissue included in the forceps is reduced to a minimum.

Fine ligature materials are preferable to coarse. The more delicate the operation the finer the ligatures (Fig. 65) *Ligatures*

Size 0000 catgut and silk presents the smallest size of ligature which can be comfortably tied by the fingers; 00000 and 000000 can, however, be readily tied with precision instruments, such as the Gillies needle holder and scissors, or fine Halsted or the Cairns artery forceps. Any surgeon who wishes to produce fine scars must practice assiduously to tie with fine suture materials.

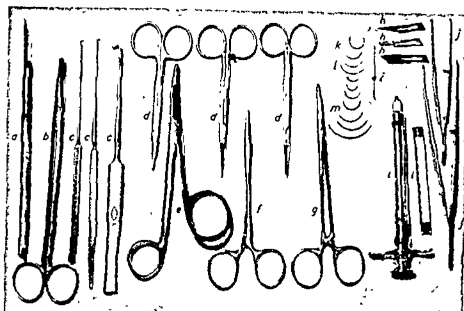


FIG 63—Instruments for fine surgical work (Gillies) (*a*) Pen for marking incisions (*b*) Scissors, 6 in., for dissection. (*c*) Hooks, single and triple pointed (Gillies). (*d*) Ophthalmic scissors, 3 types— (Gillies). (*f*) Artery forceps, 6 in (Bard Parker pattern) sizes 11, 1 needle and carpoule for local anaesthesia (*j*) Dissecting forceps—ophthalmic (toothed) and McIndoe (non-toothed). (*k*) Needle (Denis Browne), fully curved (*l*) Needles (Lane), half curved (*m*) Needles, ophthalmic, half curved



FIG. 64.—Haemostasis by forcipressure—picking up a bleeding point. Note the position of the ring finger of the left hand. This affords a firm base against which the artery forceps may be used.



FIG. 65 —Tying a knot with fine suture material: (*a*) the left hand has carried the thread over the [illegible] knot). The forceps will now be [illegible] wound; and (*c*) the left hand has carried the long end of the thread over the forceps which is now advanced to pick up the short end left on the skin at the previous stage.

(iii) *Endothermy coagulation currents.*—These are of great value when many small bleeding points must be negotiated, especially in muscles and in the depths of a wound. Picked up in long tissue forceps, the vessels may be electro-coagulated by touching the handle of the forceps with the terminal. Only the bleeding point should be so treated and the coagulation of large masses of tissue must be avoided.

While this form of haemostasis is very reliable with small vessels, it should not be employed in the case of the larger arteries lest secondary haemorrhage should occur.

(iv) *Sterile packs.*—Hot or very cold sterile packs in the wound are deservedly very popular, especially where it is inadvisable to bury foreign material, for example, under a graft.

Fibrin formation

(v) *Coagulants.*—Capillary and venular bleeding may be controlled by encouraging the early formation of fibrin. The commonest methods of achieving this are by the application of muscle grafts, and by the use of Thrombin solution, which is supplied ready to mix in strength of 5,000 units in 5 millilitres of sterile water. Thrombokinase (employed in pathological laboratories for prothrombin estimations) is as efficient in practice and is much cheaper. Fibrin foam is also extensively employed in neuro-surgical and vascular work, but the general surgeon will find the other substances sufficient for his needs.

These substances accelerate the formation of fibrin, which is a most delicate reticulum of fibrils. Once formed it is important not to disturb the mesh, or the fibrin will be disrupted and haemorrhage will recur

It is this fact which prevents the further manipulation of a wound in which haemostasis has been thus produced, and the surgeon will find that these measures are not as dependable as forcipressure and ligation.

Oxidized cellulose gauze

A modern coagulant has been devised in the form of oxidized cellulose gauze (Oxycel), which may be left in the wound. It is available also as cellulose wool. It is not handicapped by the disadvantages of the other coagulants, but sometimes increases the subsequent formation of serum in the depths of the wound

(vi) *Injection of fluid (including vasoconstrictors).*—Where surface haemorrhage (as in the excision of scars in the performance of plastic operations, or in the modern operation for closure of the cleft palate, or operations such as those on the scalp and the forehead) is liable to present difficulties from blood loss or exposure of the anatomical layers, the area may be rendered oedematous by the injection of sterile normal saline solution, with or without the inclusion of adrenaline (3–8 drops to one ounce of solution) or of a local anaesthetic substance (procaine ½ per cent). In this fashion haemorrhage during operation is considerably diminished and may contribute a great deal to a neat and accurate technique.

Intermediate haemorrhage

It should be borne in mind, however, that intermediate haemorrhage is liable to occur when the fluid has been absorbed or the action of the vasoconstrictor dissipated.

If a haematoma from such a cause should result under a graft or a skin flap, it is imperative to return the patient to the operation theatre, clean out the haematoma, and close the wound after securing haemostasis by the appropriate means.

In order to prevent this surgical accident, close attention should be paid to the method of application of a pressure dressing (*see* p. 143).

(*c*) *Sutures*

The present vogue of suturing with interrupted non-absorbable sutures is based on sound pathological investigations into the mode of healing of wounds. Wounds sutured with catgut unite by "wet" healing. This process involves a considerable oedema and giant-cell foreign body reaction to facilitate the absorption of the sutures, the fibroblastic process developing subsequently to effect firm union in the wound. *"Wet" healing*

Wounds sutured with non-absorbable sutures unite by a process of "dry" healing, with a histiocytic type of reaction leading to early fibroblastic union. *"Dry" healing*

(i) *Halsted principles*.—The employment of non-absorbable sutures, however, requires a knowledge of the basic principles involved. These principles were laid down by Halsted over fifty years ago.

(1) The suture should be braided so that slipping will not occur.

(2) The finest possible suture, compatible with the tension of apposed layers, should be used.

(3) Only interrupted sutures should be employed.

(4) No ends should be left beyond the knot.

(5) All haemostatic sutures should be sewn in position and not merely tied by hand. This is now considered to apply to very fine sutures, particularly in plastic work under grafts and similar procedures. The resulting necrosis of tissue ligated is thereby minimized due to the accurate placement of the needle.

(6) The suture should not be permitted to cross a cavity, lest it be discharged subsequently as a foreign body.

(7) Non-absorbable and absorbable sutures should not be mixed in the same wound. No unanimity of opinion exists today regarding this rule and it is considered by many surgeons that sutures may be thus combined if sterile. Surgeons accustomed to the use of absorbable sutures would be well advised to keep the possibility in mind when closing the superficial structures lest troublesome wound sinuses develop.

(ii) *Wound reaction*.—The wound reaction produced by non-absorbable sutures varies in intensity, in this ascending order: tantalum wire, stainless-steel wire, Nylon, silk, cotton and linen.

(iii) *Wire sutures*.—Because of their innocuous nature, stainless-steel wire and tantalum wire are frequently employed and may be inserted in continuous or interrupted fashion.

Once the technique of preventing coiling and kinking has been mastered (Fig. 66), the use of these substances will appeal to careful surgeons, especially when braided tantalum sutures are more generally available, for these latter do not kink. They are of special assistance in the following cases.

(1) Wounds which are oedematous at operation.

(2) Thoraco-abdominal wounds.

(3) Ventral hernia repairs, especially when Mair's skin graft procedure is favoured.

(4) Potential or actively infected wounds, for example



(*a*)



(*b*)

FIG. 66.—Inserting a continuous subcuticular suture with wire: (*a*) first stage, on the near side of the wound. Note forceps being employed to prevent kinking of the wire; (*b*) second stage, on the far side of the wound.

rectal resection with sphincter conservation, rectal repair following sacral exposure, repair of the anal sphincter, closure of colostomy, and similar operations.

(5) In the subcuticular region: (a) where it is intended to provide a cosmetic scar and, therefore, to remove the skin sutures very early in the post-operative period; (b) where a keloid has been excised and early post-operative irradiation is intended to prevent its recurrence; and (c) where a continuous subcuticular suture for skin apposition is required. (Unbraided sutures are more readily inserted and removed.)

(6) For tendon and nerve sutures.

(7) As a method of apposing aponeuroses which are under considerable tension, such as lumbar aponeurosis following laminectomy.

Generally speaking, stainless-steel Babcock wire of S.W.G. 32 is of adequate strength and, size for size, is of greater strength than unbraided tantalum wire.

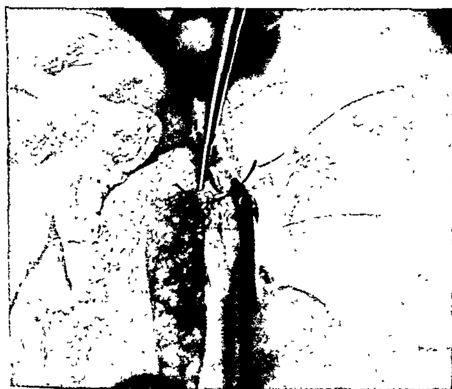


FIG. 67.—Inserting an inverted apposition suture with wire.

Inverted apposition suture

In using non-absorbable sutures, it is important to tie the knot on the deep side when the suture is close under the skin. In this fashion, ulceration of the knot through the epidermis is prevented (Fig. 67)

It should be remembered that wounds sutured with catgut and subjected to post-operative strain may sometimes burst or separate.

Wound dehiscence

To prevent dehiscence, tension sutures of silkworm gut, tied over rubbers, should be used. These sutures are often unnecessarily employed and in these modern times their use should be restricted to patients with chronic cough, urinary straining, nutritional cachexia (for example, carcinoma of the

stomach, long-standing jaundice), abdominal distension and possible wound infection.

Separation results in a wide unaesthetic scar due to stretching of the dermal fibres. This is to be anticipated in all *scars across lines of tension*, and the use of interrupted non-absorbable subcuticular sutures in these cases is worthy of consideration.

(iv) *Tying of sutures.*—While catgut may be tied in reef or granny knots, non-absorbable sutures should be tied in three knots and *cut very short.* Nylon, wire and other unbraided sutures liable to slip should be *tied carefully,* employing surgeon's knots if necessary.

(v) *Buried sutures.*—Buried sutures may be inserted in the following fashion

(1) Single interrupted sutures are inserted and tied.

(2) Single interrupted sutures are inserted and left long, all sutures being subsequently tied seriatim. This procedure permits the use of the finest size of suture material compatible with the tension of the wound, enables each suture to be inserted with great precision and, by elevating the wound edges, facilitates the insertion of the next suture (Fig. 68).

(3) Mattress sutures may be employed and tied as inserted.

(4) Figure-of-eight sutures have been shown *to represent the strongest type of stitch with* any given size of suture material. It has a very decided advantage as it is also haemostatic and is therefore of value in the scalp, in sewing bleeding points in difficult areas, in muscle layers (such as the rectus), and in some cases of secondary haemorrhage, in which the attack has been made on the bleeding point.

(vi) *Guy sutures.*—Guy sutures may first be inserted with the object of dividing into segments the area to be sewn, a procedure calculated to improve the accuracy of apposition. Further, these sutures may be employed to elevate the suture line towards the surface of the wound so that the manipulative procedures are facilitated. The skilful use of guy sutures may remove many of the difficulties in exacting operations. They are frequently employed in nerve, intestinal and vascular surgery.

(*d*) *Needles*

Sewing on the skin or on surfaces which are easily accessible may be done with sharp straight needles, but for deeper layers the modern tendency to employ interrupted sutures has made the use of curved needles more general (Fig. 63). When sewing with the curved needle, it should be remembered that the needle holder is the hub of a circle, the circumference of which is formed by the tip of the needle. This process is effected by supinating the hand.

The Singer sewing machine is favoured by some surgeons, and is used in a similar fashion to the holder and the half-curved needle. It has not, however, the finesse and precision of fine needles employed in the Gillies needle holder and scissors. In using the former instrument, the assistant ties the knots, whereas in the latter the instrument ties and cuts them.

(i) *Sewing in deep cavities.*—When sewing in deep cavities two types of needle will greatly facilitate what otherwise may be a most difficult procedure. These are, first, the Reverdin straight needle (which is obtainable in various sizes, the finest being used for the palate), and, secondly, the full circle needle of the Denis Browne and Oldfield type. The necessity for employing the

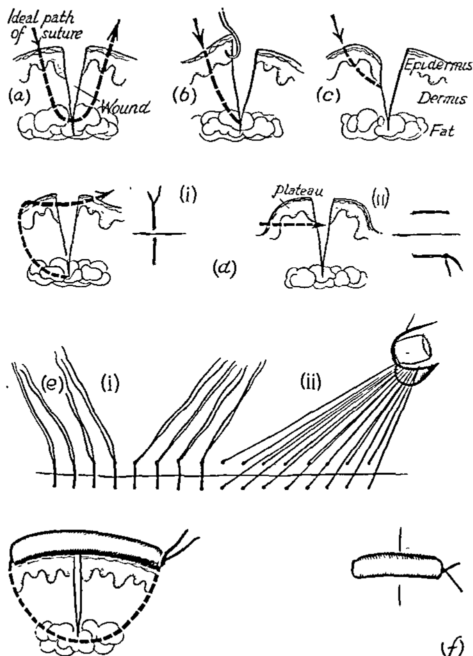


FIG 68 —Diagrams of suturing showing the following: (*a*) How a suture should be inserted to produce the best skin apposition. (*b*) Effect of everting skin edge with hook before inserting suture. (*c*) Tendency to inversion of skin edges produced by inserting suture without everting skin edge. (*d*) Mattress sutures of (i) vertical, and (ii) horizontal types. Note how the vertical mattress suture picks up the epidermal edge, and how a flat plateau (not a pyramid) is raised on the needle when inserting horizontal mattress sutures (*e*) Interrupted sutures inserted and (i) tied, or (ii) inserted, held and tied seriatim (*f*) Tension suture tied over a rubber tube The suture is inser edge equal to the depth of the wound. The rubber is twice th

needle holder as a fixed point and rotating the needle is very much in evidence when using these latter instruments.

(ii) *Fistula-pointed needles.*—Fistula-pointed needles are strong and of considerable help in dealing with aponeuroses, as they rarely break.

(iii) *Atraumatic sutures.*—In plastic procedures on nerves, blood-vessels, tendons and for cosmetic operations on the skin, the finest atraumatic needle (8–20 millimetres) is required. The handling of such needles is difficult unless special holders are employed; ordinary holders of the Mathieu and Hegar types are too coarse for this class of work. The Gillies needle holder and scissors, the Kilner holder, various modifications of the Halsted artery forceps, or the ophthalmic needle holder, are more suitable. Such surgery is facilitated by the "watchmakers' technique" advocated by Bunnell.

(*e*) *Drains*

Drainage of the wound should be carried out where sepsis or haematoma is possible or probable, where leakage from a viscus may occur, or where a residual cavity exists.

Very fine drains composed of stainless-steel wire, silkworm gut or Nylon are popular with plastic surgeons because they do not produce gaps of any size in the wound. The Penrose corrugated rubber dam is deservedly popular today for this purpose.

Sump type of drain

The recent introduction of the sump type of drain has revived interest in the glass, vitallium or other similar sump tube, into which an active suction tube may be inserted. This type of sump drain is particularly used in abdominal drainage, especially if a difficult colon anastomosis has been performed, or if fluid collections are liable to occur.

Period of drainage

Drainage tubes in the wound should be removed as soon as drainage has appreciably diminished In cases in which haematoma formation is anticipated, this may be as early as 12 hours or as late as the third day. If inserted for the drainage of pus, a longer period is required. It should always be remembered, however, that tubes retained too long may cause pressure necrosis of adjacent vessels and viscera or, of themselves, promote purulent discharge.

(*f*) *Wound closure*

It is important in wound closure to suture each anatomical layer individually.

Posterior rectus sheath

This rule applies with particular force to the posterior rectus sheath in the abdominal wall.

Unless this is done the wound will subsequently gape and result in either weakness or dehiscence, or, at the least, an unaesthetic scar. Strong layers, such as abdominal aponeuroses, require strong sutures, but once separation of the wound edges has been counteracted by adequate suturing in the deeper layers, very fine sutures can be employed for subcutaneous fasciae and fat.

The best type of scar will be produced by interrupted subcuticular suture, which thus removes all tension from the actual skin edge and enables very fine cutaneous sutures to be employed and these sutures to be removed at an early stage.

The contention that a few widely spaced silkworm gut sutures has in the past produced wounds which healed soundly and gave a satisfactory cosmetic

result is no longer tenable when one reviews facial wounds, including hare-lip repairs, so sutured. Secondary plastic suturing of such scars presents wellnigh insuperable problems if these sutures have been employed. They have no place in any wounds about the face or neck if a presentable cosmetic result is imperative, and modern suturing with fine interrupted or mattress sutures is infinitely to be preferred. Further, wounds so sutured are compatible with early mobilization—a not unimportant consideration.

Special attention should be paid to the fashion in which subcuticular suturing can be carried out, and especially to the absolute necessity for producing precise edge-to-edge apposition of the skin layer without overlap or separation. Unless the suture is inserted with the epidermal edge everted, inaccurate apposition will result (Figs. 69 and 70). *Precise apposition*

Where a gap for drainage has been left in the wound, a mattress suture properly inserted may be left untied until the drain has been removed.

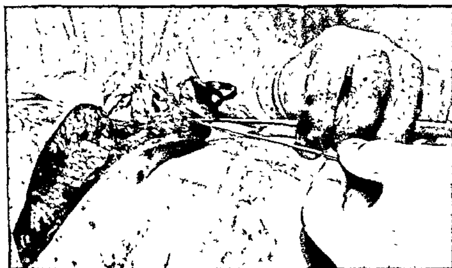


FIG. 69.—Hooks for retraction and suturing (*a*) Retraction by the Gillies three-pronged and single hooks in an operation for rotating an abdominal skin flap to cover a defect following excision of a melanoma.

If flaps have been undermined to reduce tension on the skin edges during closure, it may be possible to suture the wound directly or, on the other hand, a gap may exist. In the latter instance, skin grafting may be used if the base of the wound consists of muscle or areolar tissue. *Incomplete closure* *Free grafting*

If other structures exist in the floor of the gap (bare bone, tendon, cartilage, neurovascular bundle or joint capsule) the undermining should be extended and the undermined area transformed into a transposition, rotation or bridge flap. *Closure by plastic procedures*

When the operation has taken place through an old scar or keloid, the "Z" plastic operation is of great value, not only in closing the wound, but in preventing keloidal recurrence and contracture.

The atraumatic handling of the wound edges by very fine tissue forceps (or preferably hooks of the Gillies type) should be studied carefully.

(a)



(b)



FIG 70.—Hooks for retraction and suturing (a) use of the Gillies hook, first stage, everting the skin edge and inserting the needle; (b) second stage, everting the opposite edges and inserting the needle for the second time.

(g) *Dressings*

The smallest possible wound dressing is in vogue today so that the respiratory, abdominal and locomotor movements of the patient are in no way impeded.

Many surgeons prefer to cover their wounds with a layer of gauze or Cellophane fixed with Mastisol, collodion or glue. Others prefer large dressings fixed with strips of adhesive plaster or Elastoplast. A third method, anchor dressings (consisting of pads tied by silkworm gut tension sutures), is favoured by some abdominal surgeons.

Pressure dressings

When undermining, grafting or any plastic procedure has been carried out, however, a pressure dressing is required. If the part is liable to disturbance or movement, the sutures should be left long and tied over the pressure dressing to fix its position. In other cases, the skin is cleansed with ether and adhesive strapping is applied, or the dressing may be fixed with Mastisol

The fixation of the pressure dressing, however, is a matter of prime importance and it is preferable to take too great, rather than too little, care in this matter and, at least in the early cases, to tie all pressure dressings in position.

Composition of a pressure dressing

The pressure dressing consists of the following, from the skin outward.

(1) A layer of Vaseline gauze or Tulle Gras (the meshes of the latter are wider and more effective from the point of view of drainage).

(2) Fluffed wool moistened in paraffin or saline solution. It is important to produce elasticity by thorough fluffing. Engineers' sterile cotton waste is favoured in America.

(3) A layer of dry wool to hold the fluffed wool in position.

(4) A layer of moist gauze to form a compact dressing which can be moulded in place

(5) The fixation with sutures or adhesives.

The thickest layer should always be the fluffed wool.

When discharging vents or fistulae are close to the wound the latter should be totally occluded by cleansing the skin with ether and enclosing the wound and dressing under a protective layer of adhesive tape strips.

Immobilization

Immobilization of recent wounds is often helpful in promoting union, especially if joint movement is likely to result in separation, for example, hands, wrist, knee and axilla. Plaster-of-Paris or a similar splint is most often used.

4. SMOOTH OPERATIONS

The end-result of judgement, dexterity and experience in surgery is a smooth and skilfully conducted operation. Such operations require a minimum of post-operative care and stand in stark contrast to stormy operations which usually result in stormy convalescence.

Pre-operative planning

Smooth operations have certain well-defined characteristics By careful pre-operative planning the surgeon and his team are fully aware of the suspected condition and the proposed course to be followed. Chemotherapy, anaesthesia, exposure, lighting, retraction and resuscitation are so arranged that an error in diagnosis does not become a disaster.

Routine technique

The operation is conducted in planned stages and each stage is completed before the next is begun. This leads to the establishment of routine technique

which contributes greatly to the orderly conduct of the operation. In this regard, punctilious haemostasis (including the control of vascular pedicles before removal of any viscus) will diminish blood loss and permit an unhurried performance.

Dextrous tying of knots, a flowing technique in suturing and, above all, precision and gentleness in the manipulation of tissues—these are the aesthetic contributions of an accomplished surgeon.

[References to other titles are given under Surgical Technique in the Index Volume]

SURGICAL TECHNIQUE—WOUND DRESSINGS

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1. INTRODUCTION

317.] The primary object in every dressing is to prevent infection of the tissues deprived of their normal "skin cover". Protection from trauma and the absorption of any exudate are secondary objectives which are usually attained by the means adopted to prevent infection. In this chapter, therefore, the subject of wound dressing is treated simply as one of avoiding infection.

Lister spent his life proclaiming that inflammatory changes in wounds (wound sepsis) are due to invasion of the tissues by bacteria, and that it is the surgeon's duty to prevent that invasion. The aseptic and antiseptic ritual for the surgical theatre which evolved from his teaching was brilliantly successful; it almost completely eliminated sepsis from wounds which the surgeon made and forthwith closed. But the problem of the wound which is left open has remained. Asepsis and antisepsis—at least as practised hitherto outside the operating theatre—have failed to prevent infection in a large proportion of these open wounds.

The last 30 years have taught us some of the reasons for this failure. During World War I we learned much from the work of Sir Almroth Wright about the conditions which allow pathogens to proliferate in a wound (Wright, 1915, Wright, Fleming and Colebrook, 1918), and in recent years we have learned many new facts about the distribution and dissemination of all these wound pathogens in human communities, and especially in hospitals. We have learned, for example, that the staphylococcus is frequently present in the normal nose, that it gets from there to the skin of the hands, and, by

Distribution and dissemination of wound pathogens

the hands, may be carried elsewhere; that *Streptococcus pyogenes* is frequently present in the normal pharynx and also in the lesions of a great variety of common ailments; that both these microbes are often to be found in the air of hospital wards and on hospital bedding; and that during the dressing of wounds infected by these pathogens large numbers of them may be scattered through the air—often to a considerable distance.

In the light of these and other findings it is not surprising that asepsis and antisepsis, as practised in hospitals all over the world, have failed, for the most part, to keep the open wound free from infection, for such wounds have usually been exposed for dressing in multiple-bed wards of which the air must often have been heavily contaminated by wound pathogens. The dressing was done by a nurse or a student or an orderly who had, at best, a very rudimentary understanding of the principles of bacteriological technique which should govern this procedure. He or she had to cope with the dressing single-handed, and the equipment provided was often inadequate. In short, it must be confessed that outside the theatre no serious attempt has been made to apply the Listerian doctrine. Even in the operating theatre there is often room for improvement.

In this chapter, while keeping in mind the fact that circumstances may sometimes compel some modification, a plan of wound dressing is put forward which approaches more nearly to the Listerian ideal.

Closure of the wound

At the outset, however, it should be clearly stated that the risk of infection will always continue so long as a wound remains open, and will usually cease as soon as it regains its normal covering of skin epithelium. In other words, the best dressing for any wound is skin; and closure of the wound, whether by suture or grafting, should always be resorted to as early as possible if rapid epithelization cannot be hoped for

2. SOURCES AND CHANNELS OF INFECTION

Before proceeding to the plan for dressings it will be well to consider in somewhat greater detail what we have to guard against.

(1) The hands

Infection may come from the hands of persons carrying out "first aid"; from those of the surgeon who operates upon or otherwise deals with the injury; or of the surgical dresser or nurse who carries out his instructions; and finally it may come from the hands of the patient himself, if his fingers interfere with the dressing or actually scratch the skin in the neighbourhood of the wound. Hands cannot be sterilized by washing and soaking in antiseptics, however carefully this cleansing is carried out, although streptococci and most other potential pathogens which are not normally resident on the skin will usually be removed by this process.

From 10 to 20 per cent of normal people, however, have potentially pathogenic staphylococci on their skin (derived in many cases, it appears, from contact with the nose (Miles, Williams and Clayton-Cooper, 1944)), and sometimes such staphylococci are not eliminated from the hands by prolonged [illegible]

as from their own handkerchiefs) The special risk of [illegible]

cocci inside the surgeon's glove when he is operating, and of their escape into the wound through the accidental puncture of the glove, has been emphasized by Devenish and Miles (1939).

Contamination of the hands

Str. pyogenes may also contaminate the hands by way of salivary droplets or sneeze particles, or by contact with the skin or clothing or dressing of someone suffering from one of the many common ailments productive of streptococcus, or by infected exudates, such as are present in dermatitis, otitis media, whitlow, septic abrasions, impetigo or sycosis.

Hands so contaminated with one of these micro-organisms, or with some other pathogen, may transmit it to a wound in a variety of ways. They may do so by direct contact while the wound is being dressed, or by indirect contact *via* instruments or dressings. Another possibility which is apt to be overlooked is that a drop of fluid may trickle from a contaminated hand along the blades of instruments and so to the wound.

(2) The upper respiratory tract

Carriers of haemolytic streptococci

From 5 to 10 per cent of the population of England carry Group A haemolytic streptococci in their tonsils without any manifestations of acute infection, and tonsillitis due to such infection is a very common disease. Transmission of these streptococci to wounds may occur directly by means of salivary droplets, or by the coughing out of particles of exudate. This is especially likely to happen when there is any acute infection of the throat.

Personnel engaged on routine surgical dressings should have a bacteriological examination at regular intervals—not less than once a month—and also whenever they develop a "sore throat" or laryngitis. They should not take part in the dressing of wounds while they are carrying these organisms.

The number of nose-carriers of haemolytic streptococci is considerably smaller, but they are apt to be more dangerous than the throat-carriers, because the organisms are constantly being conveyed to handkerchiefs and so to the hands and clothing.

(3) Bedding

Blankets harbour large numbers of organisms, often including pathogenic types, which are disseminated through the air of the wards on fluff every time the beds are made and again when the floors are swept. Rountree and Armytage (1946) have reported a careful investigation of blankets from beds in an ear, nose and throat ward, and from a general surgical ward In the ear, nose and throat ward, in which there were 9 patients, a blanket from each of the 9 beds was examined. Eight of them yielded a culture of haemolytic streptococci, although only 4 of the patients had an infection caused by that organism. In the surgical ward there were 26 patients, of whom 7 had haemolytic streptococci in their wounds and 3 in their throats. Thirty-six blankets were examined from the 26 beds. Twenty-two yielded haemolytic streptococci of which 14 were from the beds of patients whose cultures had not shown the presence of that organism.

In another (less complete) investigation at the Burns Unit in Glasgow, Colebrook and his colleagues (1945) recovered haemolytic streptococci from 2 blankets which had just come back from the laundry. Both strains were serologically identical with the one which was infecting most of the patients at that time.

In most hospitals, blankets and other woollen articles such as bed-jackets and pyjamas are never sterilized in the laundry because of the risk of shrinking and "felting". An experiment in Birmingham with several new blankets showed, however, that it was the laundering that caused shrinking and felting, not the low-temperature sterilization at a pressure of 5 pounds for 20 minutes.

[illegible]

[illegible], but as these articles are changed more frequently than blankets, do not distribute so much fluff and are, moreover, boiled in the laundry, they are probably somewhat less dangerous.

From the infected bedding, pathogens can be carried to an open wound in a variety of ways, for example, they are disseminated in the air of the wards and carried by currents to any imperfectly covered (or uncovered) wound such as a burn of the face; they can contaminate the clothing and hands of nurses making the beds and from these may be conveyed to a wound while it is being dressed; they contaminate the bandages which hold a wound dressing in place and, if these bandages become soaked through with exudate or blood, pathogens can readily grow through the whole dressing to reach the wound surface (Owens, 1943; Colebrook and Hood, 1948).

(4) The air

Bacterial content of air in wards

Although Lister assumed that organisms must sometimes be conveyed to wounds from the air there were at that time few precise data as to the magnitude of this danger. Not until 1935 was it demonstrated that *Str. pyogenes* could sometimes be grown from the air of surgical wards (the burns wards of the Glasgow Royal Infirmary (Cruickshank, 1935) and the puerperal fever wards of Queen Charlotte's Hospital (White, 1936)). Nearly 10 years later the development of the "slit sampler" by Bourdillon, Lidwell and Thomas (1941) made possible a more detailed study of the bacterial content of the air and its relation to wound infections.

This investigation has shown:

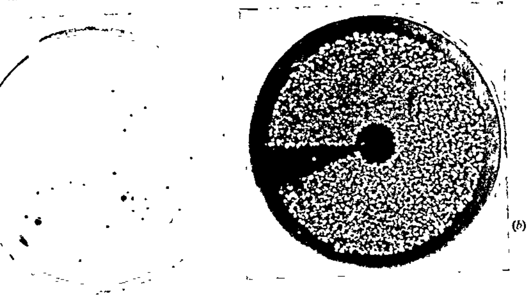
(a) That the air of multiple-bed hospital wards often carries a heavy load of micro-organisms, presumably for the most part riding on dust particles; and that this load is considerably increased whenever bedding is disturbed.

(b) That *Staphylococcus aureus* is commonly present in considerable numbers, and other wound pathogens, for example, *Str. pyogenes*, *Pseudomonas pyocyanea*, and *Bacillus proteus*, have all been found, although less frequently, when there are patients harbouring these organisms.

Scatter of bacteria in air during dressings

(c) That in the course of a surgical dressing—particularly during the removal of bandages and wool—very large numbers of bacteria are scattered into the air and can be recovered several feet away from the patient. Many of the organisms so scattered are non-pathogenic types derived from the patient's skin and bedding, but when pathogens are present on his wound these have usually been recovered from the air during the dressing (and only at that time). Such a scatter of organisms is well shown in Fig. 71.

(d) That a similar scatter of microbe-carrying particles in the air occurs whenever used bedding, particularly woollen material, is shaken within a few feet of the sampling machine (Fig. 72).

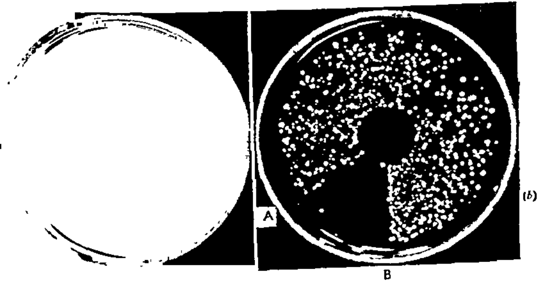


[illegible] plates exposed in the slit



3. *coli* and *D crassus* being predominant) c) One hour later—room empty for 30 minutes and positive ventilation continuing

; 72—(*a*) Plate which had revolved slowly in the slit sampler while the patient's bed was being quietly wheeled into the dressing room and before the bedding was disturbed. Only one colony has grown from the air. (*b*) From B to A (counter-clockwise) after shaking patient's nightgown 3 times within 3 feet of the sampler; 1,133 colonies have grown, representing 566 per cubic foot of air.



These findings make it clear that when open wounds are exposed for dressing in a hospital ward—and especially in a ward in which there are other patients with open wounds—the opportunity for pathogenic bacteria to settle on such wounds must occur very frequently; and the larger the wound, and the longer it is exposed, the greater the opportunity. Similar opportunity for infection must occur in an operating theatre or dressing station if provision is not made for removal of pathogens from the air.

3. PLAN TO AVOID TRANSMISSION OF ORGANISMS

The plan here suggested is substantially that adopted in the Burns Unit of the Birmingham Accident Hospital during the three years 1945-1947 (Bourdillon and Colebrook, 1946; Colebrook, Duncan and Ross, 1948). It was designed for the treatment of in-patients with large wounds, and is manifestly not practicable without some modification for the dressing of a large number of small wounds in an out-patient clinic, nor for the individual small wound in a doctor's surgery or in the home.

Essential features

In broad outline the plan incorporates the following essential features. performance of the dressing in a properly equipped room continuously supplied with filtered air in such volume and in such a manner as to sweep away all particles carrying bacteria; a team of four persons; and the use of a strict "no touch" technique.

The detail is as follows.

(1) Lay-out of the dressing room suite

The dressing room suite includes four compartments, as follows.

(a) The dressing room proper

Wash-basins

The dressing room proper should have a floor space of not less than 17 by 16 feet, and be well lit by covered-in lights on the ceiling, so designed as to avoid the lodgement of dust. It should have two wash-basins—one for the dresser and server, whose hands should seldom be contaminated, and another for the runner whose hands will often be contaminated. The water supply to each of these basins should be controlled by an arm-operated lever or by pedals, not by taps requiring manual manipulation, and by means of a thermostatic valve it should be delivered at the correct temperature for washing. The floor may be of *terrazzo* or of wood. If the latter, it should be oiled once a week with spindle oil to matt up any particles which land on it and are not swept away by the air stream.

Communicating hatchways

The room should have two hatchways communicating with an adjacent sterilizing room, one for the introduction of sterilized bowls, instruments, and so on, and the other for their return after use. Each of these hatchways should have double windows with a space of about 2 by 3 feet between them, and a mechanical device which prevents the two windows from being opened at the same time and thus provides an air-lock.

(b) The air-lock

The windows of the dressing room should be sealed. Its one door communicates with the air-lock—a chamber of not less than 16 by 10 feet floor space which leads by another door to the corridor from which patients and staff arrive for the dressing. Since the function of this room is to prevent the entry

of impure air from the corridor to the dressing room, its two doors must never be open at the same time. To this end, each door should carry a glass panel in its upper part and should also have a warning bell. The panel in the door communicating with the dressing room will be found useful also to enable a surgeon (or, on occasion, visitors) to watch a dressing in progress without dressing up and going into the room. It must be provided with a sliding opaque panel on the inside for privacy when that is desired.

(c) *The sterilizing room*

The sterilizing room, which should immediately adjoin the dressing room on one side, is for the washing-up and sterilization of used bowls, instruments, and so on, and their re-issue as required. As described above, it should communicate with the dressing room by hatchways. The actual sterilizing plant should not be on the wall between the dressing and sterilizing rooms, otherwise the heat generated from it will set up convection currents in the dressing room and to some extent interfere with the flow of air from the ceiling to the exit at floor level. *Position of sterilizing plant*

(d) *The store room*

A small room or cupboard opening out of the air-lock serves as a store for bedding and sterilized dressings. This, too, should be provided with a self-closing door.

(2) The dressing team

The dressing team should consist of:

(a) The dresser who alone deals directly with the wound. If he is conscientious about washing and avoiding unnecessary contamination of his hands, he need not wear rubber gloves.

(b) The server or trolley assistant, who assembles the instruments, bowls, bandages, and so on, and supplies them to the dresser as required.

(c) The runner (or, as she is more often termed in practice, the dirty nurse) whose function it is to remove the patient's bandages, hold a limb if required, ferry the patient in and out of the room, and assist with sundry other minor tasks

(d) The sterilizer who washes up and re-sterilizes used instruments and also, if time permits, helps with the transport of patients from the wards to the air-lock

Although it is, of course, possible for a single dressing or even a series of dressings to be done by a smaller staff, reduction of the number usually involves some relaxation of the precautions here advocated, and also results in some loss of speed. Not infrequently the dressing of a very large wound, for example, an extensive burn of a heavy patient, will require an even larger team than that described above.

Before the dressing begins, the first three members of the team put on their sterile coverings in the air-lock. First, over their ordinary shoes they pull on freshly laundered canvas boots (these should reach nearly to the knees); next, a sterile head cover which must sweep cleanly across the forehead to prevent any particles falling from the hair when the wearer bends over the patient; then a four-ply gauze mask (44 mesh) with tapes at each of the four corners and with a piece of paper or Cellophane inset to arrest the passage

of any droplets from the mouth or nose; and, finally, a sterile gown of ample proportions which gives complete cover front and back and reaches nearly to the ankles.

This sterile outfit can be worn for a series of dressings if care is taken to do the least infected cases first, and those known to be infected with haemolytic streptococci or *Ps. pyocyanea* last. It should always be discarded (into a bin provided for that purpose) at the end of the dressing session; it must never be kept from one session to the next. If any one patient is heavily infected, or his dressing necessarily involves soiling of the gown, this should be changed in any case.

Nobody should be allowed in the dressing room in any circumstances without a complete sterile outfit.

(3) Preparation of the dressing room

Preliminary purification of the air

Preparation includes not only the assembly of the equipment required for the dressing but also the preliminary purification of the air of the room to ensure that it is free from any particles carrying bacteria which may have been disseminated through it at the last dressing, or while the room was being cleaned. For this purpose the ventilation plant (described below) is switched on about 20 minutes before the dressings are due to begin. It is kept running all the time that the room is in use, and during its subsequent cleaning. An interval of 5 minutes is allowed for the re-cleaning of the air between each dressing. During this interval there should be little movement of the staff in the room.

The ventilation system

This is designed to introduce a continuous stream of filtered, warmed, and humidified air and to allow of its escape by one exit of limited size, so that a positive pressure is built up and maintained in the room, and any particles in the air are quickly swept towards and through this single exit. It is essentially, therefore, a plenum system but provides a more rapid turnover of the air (20-25 changes per hour) than is usual with such a system.

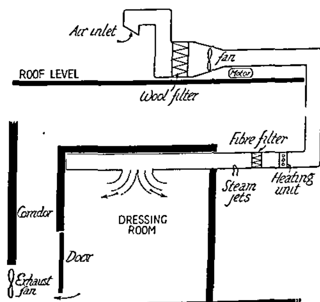


Fig. 73.—Diagram of plenum ventilating system

Its detail is shown diagrammatically in Fig. 73. The air intake is by a large duct opening a few feet above the roof of the hospital (about 75 feet from ground level). From this inlet the air is sucked by a $2\frac{1}{2}$ h.p. motor, and a fan, through a cotton-wool filter (Vokes's "Kompak"), and is then driven on over a thermostatically controlled steam-heating unit. From this it goes to a second finer mesh filter of

wool encased in a fibrous covering (Vokes's "Multivee") and then over a humidifying steam jet before it finally enters the dressing room through four multiconed orifices which diffuse it and so avoid downward draughts. After diffusion near the ceiling it drives down in piston-like fashion towards the single restricted exit at floor level. This exit should carry an extractor fan and should open directly, or indirectly by way of a duct, to the outside air. It must have a close-fitting cover to prevent the entry of unfiltered air when the plant is not in use. *The "Multivee" filter*

The heating of the room is entirely by the incoming air; there are no radiators Large dial thermometers near the door record the dry and, also, the wet bulb temperature which should be about 72° and 60° F. respectively for the comfort of both patients and staff. Occasionally, for a very sick patient who has to be exposed for an unusually long time for an extensive dressing, the dry bulb temperature should be raised to 74° or 75° F. These temperatures are maintained automatically under ordinary English weather conditions by the opening and closing of the motorized valves which control the heating and humidifying units. In exceptionally hot weather the room is apt to be uncomfortably hot unless all the air ducts outside the building are thoroughly lagged to protect them from the sun.

There is also an inclined-plane manometer in the room which shows at any moment whether the positive pressure is being satisfactorily maintained A gradual fall of pressure usually means that the Multivee filter is becoming choked by fine particles and needs to be renewed. That can be done in a few minutes and at small cost. The Kompak filter requires changing only once or twice a year.

A few minutes before the dressing begins the server enters the room in her sterile outfit, washes her hands (usually she will not need to wash again), and spreads a sterile towel over the service trolley, using long-handled supply forceps (hereafter spoken of by the usual English name, Cheatle forceps), which, when not in use, are kept with their blades immersed in an antiseptic solution. She then collects from the service hatch (*see below*) all the sterilized bowls which she will need, special trays *with covers* for the instruments, the instruments themselves, and gauze swabs. A stock of sterile bandages is also collected from a drum in the room. If there is any delay in commencing the dressing, a sterile towel is placed over the whole trolley as soon as it is ready. The server also checks the readings of the dry and wet bulb thermometer dials.

(4) Preparation of the patient

The aim in preparation of the patient is to prevent, as far as possible, any contamination of the air of the dressing room by the patient's bedding, pyjamas, respiratory tract or hair; to minimize the risk of chance contacts between any of these contaminated objects and the clothing, hands, and instruments of those carrying out the dressing, or the wound itself; and to leave a clear field for the manipulations required.

The process starts in the ward and is completed in the air-lock. The patient's upper blankets and sheet, and also his bed-jacket or pyjamas, are removed and placed on a chair. He is then covered with a freshly laundered sheet. A similar sheet is rolled under him, completely covering his under-bedding so that none will be exposed in the dressing room. He is then wheeled on his

own bed into the air-lock where the runner completes his preparation, that is to say, puts on a mask and head cover. Finally, the upper sheet is turned back from the limb (if it is a limb) which is to be dressed. He is then ready to be wheeled into the dressing room.

(5) The actual dressing

As soon as the server or dresser signals that everything is ready, the patient -still on his own bed—is wheeled in from the air-lock by the runner. From now on the guiding principle is that nothing unsterilized must be allowed to come in contact with the wound. To ensure this a strict "no touch" technique must be observed throughout: and in order still further to diminish the risk the person actually doing the dressing should keep his or her hands as far as possible uncontaminated.

The sequence of events is as follows.

The runner

The runner first washes her hands, which may have been contaminated by such objects as door-handles, and then removes the patient's outer bandages. If he has more than one wound to be dressed, these are done in sequence; two wounds must not be exposed at the same time. Safety-pins or scissors used in this operation are discarded into a sterile kidney bowl placed on the bed by the server. The runner now transfers this kidney dish to the hatch for soiled articles and then again washes her hands so as to be ready for holding a limb or giving any other help required.

The dresser

The dresser, having washed his hands for the statutory 2 minutes (a large wall clock should be provided near the wash-basin for checking this), and having dried them so that fluid will not run down his instruments on to the wound, now proceeds with the dressing. He first takes two forceps which the server hands to him with Cheatle forceps, and with them removes the wool and gauze from the wound, discarding these into a conveniently placed runabout basin on the floor.

Having discarded his forceps also, into a sterile dish placed on the bed, and received fresh ones from the server, he next takes a large sterile towel (seizing it t [illegible]
to [illegible]
of this towel is, of course, to prevent any contact, direct or indirect, between the wound and the sheet, which was contaminated by the outer bandages before these were removed.)

The dresser is now ready to do whatever may be required for the wound—to remove stitches or sloughs, to clean away purulent exudate or to apply some medicament such as penicillin cream. All this he does, of course, with sterile, dry instruments. When it is completed, he proceeds without delay to re-dress the wound. Using fresh forceps, he first applies Tulle Gras and sterile gauze or whatever material is to cover the raw surface, and over this sheets of cotton-wool large enough to overlap the gauze in all directions by at least 1 inch, and thick enough to afford an adequate bacterial filter—to protect the wound against infection from the air just as the bacteriologist's cotton-wool plug does in his test-tubes. This function of the wool is often not appreciated by those who teach students and nurses, and certainly not by those who do dressings. In very extensive burns it has sometimes seemed that the application of so much cotton-wool, covering perhaps 70 per cent or more of the

Protection against air-borne infection

body-surface, seriously interfered with heat regulation and embarrassed the respiratory system. The way out of this dilemma is by no means clear: it may be necessary to nurse such patients without any dressings, in a tent supplied with filtered air.

Finally, the dresser discards his forceps—he may have had to do so when applying the cotton-wool to a dependent surface—and applies the bandages with his hands. This part of the dressing is perhaps the most important of all—and often the worst done. If the dressing is allowed to skid at any time between one dressing and the next—perhaps a week later—there will be ample opportunity for dust particles in the ward to convey pathogens to the wound. *Crêpe* bandages are almost essential for adequate fixation of any large dressing which is not to be changed for several days, and even these will often need to be supplemented by strips of surgical strapping or by a thin shell of plaster of Paris. Such plaster shells have proved invaluable for children with burns of the neck and shoulders or upper chest, and also after the application of skin grafts. They not only keep the dressing in place, but also prevent interference by the patient's fingers

Adequate fixation of dressing

One more protective device needs to be mentioned. It has recently been shown (Owens, 1943; Colebrook and Hood, 1948) that if a dressing becomes soaked with serous exudate (or blood), as not infrequently happens in burns, it becomes in effect a semi-solid mass of nutrient culture medium through which any pathogens arriving on the outer bandages can readily grow and invade the wound. This can be prevented by interposing a sheet of Cellophane between the cotton-wool and the bandages. The Cellophane should not, however, completely seal the whole dressing, otherwise the wound is liable to become sodden and healing is retarded A better barrier material is being sought (Moss and her colleagues, 1948)

4. MODIFICATIONS APPLICABLE TO OUT-PATIENT DEPARTMENTS

For the hospital out-patient department which has to deal with many small wounds in a short time, the elaborate precautions sketched above will need to be modified to some extent. The smaller size of the wounds and the shorter exposure of them during their dressing will diminish the risk of air-borne infection but there is little doubt that that risk is still considerable, and a serious attempt should be made to reduce it. Air-conditioning by the plenum system, as described above, must necessarily be much less effective if patients (in their outdoor clothes) are constantly passing in and out of the dressing room; and it would be quite impracticable to wait for 5 minutes between each dressing. In these circumstances, purification of the air by electrostatic precipitation might prove a better method, but the installation of the apparatus would be costly, and there are at present few data available as to the efficacy of the process for the removal of very small particles

Purification of the air

Pending further investigation of this problem, much can be done, however, to reduce the risk of contact infections by attention to the organization and technique of dressings. The general principles are the same for the small as for the larger wound—it must not be touched by the dresser's hand either directly or indirectly, or with anything unsterilized. To accomplish this the

dressing should be done by a team of two or, better, three persons; the dresser must wash his hands scrupulously but must work with them dry; and he should rely upon a strict "no touch" technique. Gissane, Miles and Williams (1944) have emphasized the importance of design of the dressing room if loss of time and efficiency are to be minimized, the dresser being so placed that he is within easy reach of the patient, the server and the wash basin, almost without moving.

5. CONCLUSION

It must be frankly recognized that the dressing procedure advocated here—or any other which has a similarly comprehensive aim—will be troublesome and expensive But the experience in Birmingham has shown clearly that the objective aimed at can be attained; the trouble has been abundantly justified by the improved clinical results; the expense also has been justified by the great reduction in the period of hospitalization, quite apart from the benefit to the patients.

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SYPHILIS

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1. INTRODUCTION

318] In surgical practice syphilis may be encountered in any of its stages and the surgeon may be required to treat syphilitic lesions in any part of the body. In general, the approach to the treatment of acquired syphilis leads to two main practical divisions of the infection: (1) that of "early" syphilis which includes the primary and secondary stages and the first 5 years of the latent phase; and (2) that of "late" syphilis which includes tertiary lesions of diverse character and location, and the latent phase after the first 5 years. The choice of treatment is by no means identical for every patient.

2. GENERAL MANAGEMENT OF EARLY SYPHILIS

Factors influencing mode of treatment

The general management of the syphilitic patient is dependent upon various factors which may influence the extent and efficiency of treatment. Prominent among these factors are the stage of the disease, the degree of its infectivity, the structures affected and the extent of damage, all of which need to be judiciously assessed before the surgeon can decide what remedies are most suitable and what prognosis may be given Infection with syphilis frequently has public health and domestic repercussions in addition to the individual requirements of the patient. The former demand the speedy control of the

contagious lesions together with advice to the patient upon the infectivity of the disease and instruction upon the behaviour which will limit the spread of the infection to others. The individual aspect necessitates treatment which will heal the lesions rapidly and restore health with a minimum of interruption of the daily occupation. Conditions of confidence and secrecy should be maintained.

Continuation of treatment

In the management of early syphilis certain general principles are applicable to the great majority of patients. Specific treatment should be commenced as soon as a diagnosis is made but should not be started until the diagnosis of syphilis has been established with certainty. The treatment of the infection should not cease with the disappearance of the signs and symptoms but should be designed to achieve the complete eradication of the infection.

The importance of early diagnosis

Classical Hunterian chancre now rare

Besides accuracy in diagnosis, speed in arriving at a diagnosis is also of importance because the sooner recently acquired syphilis can be diagnosed and treated the more favourable is the prognosis The results of the treatment of primary syphilis while the serological tests are still negative are considerably more favourable than when it is delayed until after they have become positive. Within the last 10 years, and particularly during World War II, the general knowledge of the young adult male population on venereal disease has been at a much higher level than formerly. A practical result of this knowledge is that the young male infected with syphilis tends to seek advice when the initial lesion has been visible for a matter of a few days only. At this time the "sore" is often no more than a tiny superficial erosion with but little induration in the margin of the lesion. The classical Hunterian chancre—the fully developed chancre of 3–5 weeks maturity—is becoming a rarity. In these early undeveloped chancres the Wassermann reaction does not become positive for several weeks.

Diagnostic methods in primary syphilis

Dark-field microscopy

Repeated tests necessary

An accurate diagnosis can be established only by the recognition of the characteristic spirochaete in the secretion from the sore Fortunately for the purpose of diagnosis *Spirochaeta pallida* can be readily found in the secretion of these early and often trivial-looking erosions Although spirochaetes may sometimes be found in the moisture on the surface of the lesion, for the purpose of thorough dark-field microscopy it is essential to obtain the secretion expressed from the base of the sore by circumferential pressure for several minutes after a preliminary cleansing with saline solution. When dark-field microscopy is not available nearby, the secretion can be collected in a capillary tube which, after sealing, can be sent to an appropriate laboratory or clinic, or, even better, the patient can be sent for such examination. The omission of dark-field microscopy and the delay until the development of the typical characters of a Hunterian chancre and of a positive Wassermann reaction will postpone the commencement of treatment to a time in the evolution of the infection when the prospect of cure is less favourable. Summarily to dismiss an erosion or ulcer of short duration in the genital area as being non-syphilitic on the strength of a single negative Wassermann test, and without dark-field microscopy, is gross negligence.

3. PENICILLIN THERAPY

The modern treatment of syphilis is based upon the use of two well-tried remedies—the organic arsenical compounds and bismuth—together with that of penicillin, the anti-syphilitic action of which is still incompletely assessed.

Treatment by means of penicillin alone

In most of the early cases of syphilis treated by means of penicillin alone, 3-hourly injections were given for a period of 7–8 days. When the total dose was small (60,000–300,000 units) (Moore, 1945) relapses occurred in 40–60 per cent of the cases in the first year. Moderate total dosage (600,000–1,200,000 units) reduced the relapse rate in the first year to 26–18 per cent (Committee on Medical Research, 1946). An increase in the total dosage to 2,400,000 units reduced the relapse rate still further, although not proportionately, to 12–15 per cent (Committee on Medical Research, 1946). The use of massive doses of penicillin in 24 hours has not produced encouraging results. A total amount of 15,000,000 units, given by the continuous drip method, was followed by 66 per cent of failures, and a total dosage of 25,000,000 units by 35 per cent of failures by the end of 12 months (Peters and Barton, 1947). Large doses of penicillin, for example, 1,000,000 units daily for 3, 4, or 5 days, have given a relapse rate of about 50 per cent (Lloyd-Jones, Allen and Donaldson, 1946). The most recent evaluation of penicillin therapy for early syphilis at the end of a 2-year observation period indicates a failure rate of 25 per cent (Moore, 1948).

Percentage of failures in treatment

Since it became clear that penicillin alone, in spite of its remarkably prompt healing action on the surface lesions of syphilis, cannot eradicate the infection in all cases, the arsphenamines and bismuth, which had been displaced from syphilis therapy by some authorities, have become reinstated as a necessary part of treatment.

Arsphenamines and bismuth

The difficulty of providing hospital accommodation for the 3-hourly, 7–8 day schedule of penicillin therapy has led to the introduction of penicillin incorporated in slow-release vehicles of which bees-wax and arachis oil has been found to be the most suitable (Romansky and Rittman, 1944) After an injection of 600,000 units in this medium, penicillin is present in the blood for 24 hours (May, 1948). This method is now used extensively for the treatment of syphilis in ambulant patients who receive single daily injections for 8 days.

Penicillin in wax and oil

4. COMBINED TREATMENT OF EARLY SYPHILIS

The aim of treatment in these early cases is not only to heal the lesions and to prevent further dissemination of the disease but to eradicate the infection. Although in some cases penicillin alone is capable of eradicating syphilis in its early stages, a complete cure cannot be obtained in all cases. Also, there is no known method of ascertaining which cases are likely to be so cured. Penicillin is therefore used in combination with neoarsphenamine and bismuth. The introduction of penicillin into syphilis therapy, however, has shortened the period of treatment from 12–18 months to 3–6 months, and therefore a far greater proportion of patients actually complete the planned schedule of treatment.

(1) Schedule of treatment

Aqueous sodium penicillin

In hospitals or nursing homes, aqueous sodium penicillin, in intramuscular injections of 60,000 units, is given at 3-hourly intervals for 7½ days; 60 injections comprise a total of 3,600,000 units. When hospital accommodation is not available, or is refused by the patient, treatment should be carried out on an ambulant basis. For this purpose intramuscular injection of calcium penicillin in an oil and wax medium is used. The amount injected once each day for 8 days is 600,000 units (total 4,800,000 units). Penicillin urticaria, which occasionally ensues, is treated orally by means of Benadryl in doses of 50 milligrams thrice daily.

Calcium penicillin in oil and wax

Neoarsphenamine

During the penicillin therapy 0·3 gramme of neoarsphenamine is given intravenously on the second day, and 0·45 on the sixth day. The same dose of 0·45 gramme of neoarsphenamine is given on the ninth and twelfth days. Thereafter, for an additional 6 weeks, neoarsphenamine is given in doses of 0·6 gramme at weekly intervals. A total amount of 5·25 grammes is thus reached. These amounts of neoarsphenamine are maximal and should be reduced for patients—usually women—whose weight is under 10 stones (63·5 kilograms). For those of particularly light weight the individual maximal dose is calculated at the rate of 0·004 gramme per pound of body-weight; thus a person weighing 7 stones, 2 pounds, should receive 0·4 gramme as the maximal weekly amount. On completion of the 8-day period of penicillin therapy and during the subsequent arsenical therapy, bismuth oxychloride, 0·2 gramme, is administered by intramuscular injection once a week during the next 6 weeks; it may be given at the same sitting as the neoarsphenamine or on a separate day but the 7-day interval should be maintained.

Bismuth oxychloride

It is a practical experience that many patients have some difficulty in arranging at short notice a daily attendance for 8 days. Usually, regular attendances can be commenced within a few days. While these arrangements are being made, treatment with neoarsphenamine and bismuth should be commenced immediately so that the progression of the infection may be prevented.

TABLE

TREATMENT OF EARLY SYPHILIS IN AMBULANT PATIENTS

DAY	PENICILLIN IN OIL AND WAX (Units) Intramuscular	NEOARSPHENAMINE (Grammes) Intravenous	BISMUTH OXYCHLORIDE (Grammes) Intramuscular
1	600,000	–	–
2	600,000	0·3	–
3	600,000	–	–
4	600,000	–	–
5	600,000	–	–
6	600,000	0·45	–
7	600,000	–	–
8	600,000	–	–
9	–	0·45	0·2
12	–	0·45	0·2
19	–	0·6	
and 5 further weekly doses	–	3·0	1·0
Total	4,800,000	5·25	1·4

Under this schedule of combined treatment the lesions of the primary and secondary stages heal rapidly and completely. When treatment is begun early the Wassermann reaction may never become positive. In serum-positive primary cases there is a gradual decrease in the titre of the Wassermann reaction to a negative result in the third or fourth month from the commencement of treatment. The persistence of a strongly positive Wassermann reaction up to the sixth month indicates a failure to control the infection. Additional treatment with a similar course of the three anti-syphilitic remedies is then necessary. In cases in which the reaction is weakly positive at the sixth month it may become negative during the next few months and immediate re-treatment is not usually considered necessary. The Wassermann reaction should be undertaken at monthly intervals so that any rise in titre of the reaction may be observed. This rise should be interpreted as portending a relapse, and re-treatment is advisable. *[illegible]* *Relapse*

(2) *Local treatment of chancres*

Local treatment for small clean chancres is rarely necessary, as they dry up rapidly under systemic treatment. When a large chancre is secondarily infected, or an accompanying balanitis is evident, local bathing with hydrogen peroxide for several days is advisable, after which penicillin cream may be applied. Foul, sloughing, ulcerated chancres are best treated by the application of flowers of sulphur, after prolonged soaking in hydrogen peroxide. When phimosis prevents efficient bathing, the preputial sac may be irrigated by means of hydrogen peroxide and a rubber catheter. When phagedaena seems impending, dorsal incision of the prepuce may be required. *Secondary infection* *Phagedaena*

(3) Chancroid ulcer

Chancroid ulcer (soft sore), due to infection by a streptobacillus, *Haemophilus ducreyi*, may simulate a syphilitic chancre. *S. pallida* is not found in the secretion from the sore and the ulcer makes no response to penicillin or to arsenical treatment. In the majority of cases rapid healing of the sore, and subsidence of the inguinal bubo, is effected by means of oral administration of sulphathiazole, 4 grammes daily for 4–7 days, together with the local application of sulphathiazole powder after bathing with a mild antiseptic solution. Intractable ulcers may respond to intravenous injections of the vaccine of the infecting streptobacillus (Dmelcos). *Sulphathiazole*

(4) Tests of cure

All patients with early syphilis who appear to have been successfully treated should be kept under clinical and serological observation at regular intervals for a period of 3 years. Serological tests should be carried out at monthly intervals during the first 3 months, at 3-monthly intervals for the next year and thereafter at 6-monthly intervals. The cerebrospinal fluid should be examined at the end of the first year after treatment. The patient may be considered free from infection if, at the end of 3 years, all clinical and serological observations have shown no evidence of the disease.

(5) Syphilis in pregnancy

The treatment of syphilis during pregnancy calls for special consideration. Usually the patient is a young adult whose toleration for bismuth and the

Combined course

arsenicals is good. A combined course of penicillin, neoarsphenamine and bismuth, as laid down for the treatment of early syphilis, should be commenced as soon as possible. Women rarely attend for treatment before the third month of pregnancy, so that the interval between the end of the course of treatment and the birth of the child is about 3 months. If the Wassermann reaction is still strongly positive 1 month after treatment a second course of penicillin alone, amounting to a total of 4,000,000 units, is advised. In many cases, however, the syphilitic infection is not recognized until later in pregnancy and there is insufficient time before delivery to complete the full course of treatment. Fortunately, however, penicillin therapy alone, even when it is not given until the later months of pregnancy, has produced excellent results as regards the protection of the child from infection (Ingraham and his colleagues, 1946). The mother may require additional injections after delivery in order to complete her treatment.

Penicillin alone

5. TREATMENT OF LATE SYPHILIS

Syphilis is usually acquired by the young adult in whom the infection tends to develop along characteristic lines. To such patients a routine schedule of treatment is usually applicable. In tertiary syphilis, however, routine treatment is inappropriate because of the great variation in the age of the patients, the nature of the structures involved, the extent of the damage and the presence of other diseases. The treatment of tertiary syphilis is essentially treatment of the patient rather than of the disease. The main objectives in view are to prevent further extension of the disease, to attain resolution of the existing lesions and to restore the damaged structures and the impaired functions so far as is possible. The general condition of the patient and in particular the state of the heart, liver, lungs and kidneys must be considered. In these late cases much harm to the general health may be caused by intensive treatment, particularly with the arsenical compounds, at a time when the complete eradication of syphilis is impossible. In general, treatment at this stage should be moderate in degree and leisurely in pace, but of prolonged duration.

Main objectives

(1) Latent syphilis

One of the common problems in the management of syphilis in middle-aged and elderly patients is that of the treatment of "latent" syphilis. This torpid phase of the infection has been aptly defined by Stokes (1934) as "a period of high resistance and low visibility with an undercurrent of chronic mild inflammatory change in vital structures". The term "latent" syphilis is applied to those cases of syphilis in which positive serological tests are obtained repeatedly and in which no signs of the disease can be detected by thorough clinical examination. In view of the fact that errors in laboratory technique or in recording are not unknown and that biologically false-positive serological tests are occasionally reported, it is imperative to repeat the Wassermann reaction, and to obtain the result of a flocculation test such as the Kahn in addition, before the presence of syphilis is accepted. The so-called provocative Wassermann test is no longer considered to be of any value. The diagnosis of the state of "latent" syphilis is one that is arrived at

Flocculation tests

by elimination and should not be accepted without x-ray examination of the heart and aorta and tests of the cerebrospinal fluid. The use of the term "latent" tends to give both surgeon and patient a feeling of false security. It is as well to remember that all cases of syphilis with tertiary lesions can give a long history of "latency", and that "latency" in a woman commonly results in syphilitic offspring.

Radiological examination

However well the patient may appear, treatment of latent syphilis is necessary in order to prevent the development of tertiary lesions, especially those of vital structures. The type of treatment will depend upon an estimate of the duration of the infection. Sometimes the date of the infection is known by the patient, but more commonly there is no knowledge of when infection took place. When it is known or estimated that syphilis was acquired less than 10 years previously, and if the patient is free from other diseases, the treatment should be according to the schedule laid down for the cases of early syphilis. This should, however, be preceded by treatment with potassium iodide, 30 grains daily, and with weekly injections of a bismuth preparation for 1 month. In the pregnant woman no time should be wasted on preliminary treatment, and the full schedule as for early syphilis should be commenced without delay. The positive results in serological tests in latent syphilis are usually reversed very slowly by treatment and the course may have to be repeated 2 or 3 times.

Potassium iodide and bismuth

(2) Tertiary lesions

In the tertiary stage gummatous inflammation frequently affects the structures of the skeletal system. The lesions are of slow formation and benign nature. There is little adverse effect upon the general health of the patient, although over a long period of time the extent of local destruction may be considerable. Fortunately, even in aged patients, gummatous ulcerations of the skin or mucous membranes respond speedily even to mild treatment. Resolution can be effected by means of potassium iodide, 60 grains daily, together with injection of a bismuth compound (0·1 gramme of the oxychloride) once a week for 4–8 weeks Penicillin is also effective in such cases. Cutaneous ulcers heal rapidly when penicillin, 250,000 units in oil and wax, is given as infrequently as once a week. For patients over the age of 60 years, penicillin in oil and wax is injected twice a week in doses of 250,000 units, and potassium iodide is given by mouth in doses of 20 grains thrice daily for 4 weeks. Later treatment is carried out with bismuth oxychloride, in doses of 0·1 gramme given once a week for 8–10 weeks. The condition of the gums and teeth should be inspected and attended to, if necessary, before prolonged bismuth therapy is undertaken Organic arsenical preparations are not necessary in the treatment of these elderly people and should not be used The positive serological tests will remain unaffected, as they will be by any form of treatment at this age, and should not constitute a guide to further treatment

Gummatous lesions

Organic arsenical preparations contra-indicated

In patients with late cutaneous syphilis, who are under 60 and, more particularly, between 40 and 50 years of age, there is a greater likelihood of the future development of neurosyphilis or cardiovascular syphilis. Sometimes, but not commonly, one or other of these conditions is already present but has not been recognized All patients with gummatous syphilides should

Late cutaneous syphilis

undergo the same rigorous clinical examinations as are specified for laten syphilis. Even when no other signs of syphilis can be found, more extensiv treatment is advisable during this age period in order to forestall, if possibl the later involvement of vital structures. Preliminary treatment should b commenced with potassium iodide, 10 grains thrice daily, and a weekl injection of 0·2 gramme of bismuth oxychloride for 4 weeks. Penicillin 600,000 units in oil and wax, should then be given daily for 8 days. This is followed by weekly injections of neoarsphenamine, commencing with 0·3 gramme and increasing up to 0·6 gramme for 8 weeks, after which additional 4-weekly injections of bismuth oxychloride are given. After an interval of 1 month a second similar course of treatment should be given. When the patient's health is not good the intravenous neoarsphenamine may be replaced by Acetylarsan, given by intramuscular injection, in doses of 3 millilitres once a week for 10 weeks.

Acetylarsan

Syphilitic disease of bone is considerably more difficult to deal with than is that of the skin. When a nodular cutaneous syphilide is situated over superficially placed bone, such as the tibia, sternum or bones of the skull, an underlying periostitis is frequently present. This local periostitis responds to treatment less speedily than the overlying ulceration. Although symptomatic relief may be obtained in a few weeks, several months of treatment may be required before the bone disease is arrested. Isolated disease of bone is also slow to respond to treatment and in syphilitic disease of bone it seems that the duration of treatment is more important than the intensity. The few reports available of the value of penicillin in syphilitic osteomyelitis show, as with the arsenical compounds and bismuth, that symptomatic relief may be prompt but ultimate resolution is very slow (Dexter and Tucker, 1946).

Localized periostitis

Syphilitic osteomyelitis

(3) Serological tests

The effect of anti-syphilitic therapy upon strongly positive serological tests is slowly to reduce the titre until finally a negative result is obtained. The period required to attain this result varies with the duration of the infection and with the amount, regularity and duration of the treatment. In early syphilis a strongly positive reaction may be decreased within a few weeks, but it does not usually become negative until 3–4 months from the beginning of treatment. The period is much the same whether arsenical preparations or penicillin, or both, are used (Clark, Maxwell and Scott, 1947). The negative reaction in these early cases may not be permanent and the serum may become positive again some months later, especially when treatment has been incomplete or irregular. Experience has shown that a serological relapse should be regarded as indicating a general redissemination of spirochaetes. Full treatment should therefore be recommenced at once. In the tertiary stage and in late congenital syphilis, treatment over several years may be needed before the strongly positive reaction is affected, and in many cases the reaction persists unchanged in spite of heavy and prolonged therapy. The tertiary lesions of the skin, however, usually heal rapidly under appropriate treatment, notwithstanding the persistently positive reaction in the blood.

Relapse

6. CONGENITAL SYPHILIS

It should be emphasized that congenital syphilis is a disease which should

seldom or never require treatment since adequate measures for its prevention are available. The successful management and control of congenital syphilis is dependent upon the early recognition and treatment of the disease in the mother. If every pregnant woman had a Wassermann test done during her pregnancy, and if, in every case, syphilis thus discovered were treated, congenital syphilis would become almost extinct. The various remedies which are successfully employed in acquired syphilis in the adult are equally effective in the infant.

Preventive measures

(1) Treatment in infancy

The freedom of penicillin from toxic effects and its rapid healing effect on active syphilitic lesions render it a most valuable remedy for the initiation of specific treatment of the infant. The immediate effects of penicillin therapy are excellent. The general condition improves rapidly. In the skin and mucous membranes, lesions heal speedily and the osseous lesions undergo complete resolution in 3–4 months (Yampolsky and Heyman, 1946).

Effects of penicillin therapy

The problem of treatment of the apparently healthy infant born of a mother known to be syphilitic requires some consideration. A positive serological reaction in the blood from the umbilical cord is by no means proof of infection of the new-born infant. It may merely reflect the serological reaction of the mother's blood. In the uninfected infant, when a serological test on blood from the umbilical cord is positive, the child's blood may give a positive result at birth. The reaction declines in intensity during the next few months and it usually becomes negative between the fourth and the sixth month. In such a case the infant should not receive treatment but should have repeated clinical and serological tests for at least 6 months. A persistently strong positive reaction in the infant's blood, or an increase in the intensity of an originally weakly positive reaction, should be interpreted as indicating infection and the infant should then receive treatment.

Serological tests

Penicillin is given by intramuscular injections at 4-hourly intervals in the young infant in whom, on account of the slow renal clearance, the blood level of penicillin is maintained for a longer period than in older children; after the age of 6 months, penicillin should be given at 3-hourly intervals. The dosage advised is 1,000 units of penicillin for each pound of body-weight in each injection, and this dosage should be maintained for 14 days. Preparations of penicillin in oil and bees-wax are not suitable for repeated injection into the infant's buttocks

Dosage

When there is any delay or difficulty in arranging for the course of multiple injections, treatment may be commenced with the oral administration of penicillin. This is given at the rate of 10,000 units for each pound of the infant's weight, in each 4-hourly feed for 7–14 days

The penicillin therapy for congenital syphilis should be followed by weekly injections of arsenical preparations and of bismuth, both of which are well tolerated by children. Since intravenous injection is difficult in children under the age of 6 years, reliance is placed upon sulpharsphenamine given by intramuscular injection. This arsenical may be given to an infant a few weeks old in doses of 0·005 gramme, increasing each week by graduated amounts to 0·05 gramme at the end of a course of 8 weekly injections. If the injection causes local pain or swelling, Acetylarsan (in the preparation designed

Sulpharsphenamine

for administration to children) may be substituted, the dosage being at the rate of 0·5 millilitre for each 8 pounds of the child's weight. This is followed by intramuscular injections of a metallic bismuth suspension given in a dosage of 0 02 gramme each week for 8 weeks.

If at the end of 6 months from the commencement of treatment the serological tests are still strongly positive, the penicillin, arsenical and bismuth courses are repeated. If the serological tests are negative, treatment may be withheld and the tests repeated at 3-monthly intervals for 12 months and at 6-monthly intervals for 3 years.

Dosage in older children

Older children require larger amounts of the arsenical and bismuth compounds. For a child 1 year old and of normal weight, the sulpharsphenamine injections are increased gradually from an initial amount of 0 025 gramme up to 0·1 gramme per week in the fourth to the eighth week. Bismuth is then given in amounts equivalent to 0 04 gramme of bismuth metal each week.

Since children affected with congenital syphilis are frequently debilitated and underweight, the amounts of the arsenical and bismuth remedies to be administered should be considered in terms of weight of the child rather than of age. In general, after the age of 3 months 0 005 gramme of sulpharsphenamine may be given for each pound of the child's weight as the maximal weekly amount in a series of injections. Thus, for a child weighing 30 pounds, the appropriate initial dose of sulpharsphenamine is 0 06 gramme and the maximal weekly dose is 0 15 gramme.

Periodical tests necessary

After apparently successful treatment the child should be subjected periodically to close clinical and serological observation until after puberty. The cerebrospinal fluid should be examined in all cases in which there is a persistently positive result in serological tests after 2 courses of treatment.

(2) Delayed congenital syphilis

In many cases of infection, the periods of infancy and early childhood are passed in good health. Later, usually between the sixth year and puberty, but sometimes in adolescence, isolated lesions, such as interstitial keratitis, periostitis, gummatous ulceration of the palate or nerve deafness, may develop. Treatment is carried out along the lines indicated but repeated courses may be found necessary over several years to effect cure. The Wassermann reaction may remain unaffected by treatment but in adult life tends to decline in titre and eventually may become negative.

Response of individual lesions

The response of individual lesions is remarkably variable. Gummatous ulceration of the skin, palate and pharynx usually heals readily, as it does in the adult. Deafness due to involvement of the eighth nerve is, as a rule, of sudden onset and complete. The damage is usually permanent and is not improved by treatment. Incomplete nerve deafness may be arrested if treatment is very promptly given, but improvement, however, is rare.

Interstitial keratitis is slow to respond to treatment whatever agent or combination of agents is employed. When one eye only is affected the involvement of the second eye is a very likely event whether or not treatment has been commenced. One of the factors responsible for the comparatively poor results of treatment is probably the very restricted penetration of the antisyphilitic drugs into the ocular tissues. Treatment should be both vigorous and prolonged. Repeated subconjunctival injections of penicillin are considered

by some ophthalmic surgeons to be more effective than is systemic therapy in this condition.

7. VISCERAL SYPHILIS

(1) Liver

Gummas of the liver, if not of long duration or of large size, respond well to specific treatment. If, however, the gummatous process has been slowly developing for many years before it is recognized, the response to treatment is slow and resolution may not be complete. When only a few gummas are present and are limited to one lobe of the liver the prognosis is good; but when many large gummas can be felt and gross irregularity indicates that contraction and distortion of the liver has already begun, some slight gradual improvement is all that can be expected. When ascites is present specific treatment is usually of no value. In hepatic syphilis there is a natural tendency towards resolution with fibrosis and contraction to the detriment of the hepatic lobules. Since this tendency is accelerated by specific therapy such treatment should be mild and prolonged. Iodide treatment will give relief from pain and tenderness in a few weeks; and for the first 2–3 weeks potassium iodide only, in doses of 10 grains three times a day, is recommended. Subsequently, penicillin in modest dosage, 100,000–200,000 units, is given twice weekly for 6–8 weeks. Additional treatment with potassium iodide and with injections of bismuth oxychloride, 0 1 gramme once a fortnight, should be maintained over a period of six months. The use of the arsphenamines is not advised. After an interval of a month another similar course should be given. If, as often happens, there has been a speedy relief from pain and a rapid decrease in the size of the swelling within a few weeks, some palpable swelling may remain for several years before ultimate absorption is achieved. In some cases, therefore, prolonged treatment is advisable.

Slow response to treatment

Treatment

(2) Testis

A gumma of the testis responds rapidly to specific treatment but after resolution the testicular tissue is usually atrophied and functionless.

(3) Tongue

The uncommon tertiary gummatous ulcer of the tongue also heals speedily under treatment although there may be considerable sloughing in the first week. Leucoplakia of the tongue seems little influenced by specific therapy but fissures will often heal, with gratifying loss of pain. Bismuth has been more useful in my cases than any of the arsphenamines. Carcinomatous ulcers of the tongue are not influenced by treatment with potassium iodide, bismuth or the arsphenamines. Penicillin, however, may clean the surface of the ulcer and diminish the surrounding swelling, and, therefore, this antibiotic should not be given if anti-syphilitic therapy is being used as a therapeutic test in lingual ulcers of a doubtful nature.

Treatment

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the external ring and turned upwards towards the anterior superior spine of the ilium. Such a testis usually preserves considerable mobility so that it can be pushed back into the dilated external ring.

(*b*) *Pubic*

In this case the testis lies at the root of the penis.

(*c*) *Perineal*

The testis passes to the outer side of the scrotum and comes to lie behind it.

(*d*) *Femoral*

The testis passes downwards into the femoral triangle.

(3) Pathological anatomy

Potential hernia

The imperfectly descended testis is smaller than normal and has a well developed mesorchium joining it to the epididymis and parietal layer of the tunica vaginalis. In the majority of cases the processus vaginalis remains patent constituting a potential hernia and interfering with the normal descent of the testis. In addition there are fibrous bands in the cord which produce shortening. The vas and the vessels may also be relatively short preventing adequate mobilization of the testis. It may be possible to overcome this shortening by dissection of the cord bundle in the retroperitoneal tissue and by division of the deep epigastric artery.

(4) Function in the imperfectly descended testis

Scrotal temperature

Internal secretion is unaffected but external secretion, that is to say spermatogenesis, is absent. If a microscopic section is examined the interstitial cells appear unduly prominent owing to the complete lack of differentiation of the spermatogonia which appear as solid cords of cells. The reason is unknown but it is a definite fact that the scrotal temperature is slightly lower than the intra-abdominal temperature and also that the scrotal testis is not subjected to repeated alterations of pressure as is the intra-abdominal testis.

Hormone deficiency

A relative deficiency in anterior pituitary hormone may be a contributory cause although in unilateral cases the opposite testis appears entirely normal. If the testis remains outside the scrotum it tends to atrophy and may be affected by repeated attacks of traumatic orchitis.

(5) Complications

(*a*) *Hernia*

Interstitial hernia

The processus vaginalis usually remains patent and of sufficient size to permit the entry of abdominal contents. Occasionally a bilocular sac may be present with a loculus lying between the layers of the abdominal wall—interstitial hernia. In imperfect descent the sac usually lies between the external and internal oblique muscles—interparietal, or occasionally deep to the abdominal muscles—properitoneal In the ectopic inguinal testis the sac lies between the muscles and the deep fascia of the abdominal wall—proparietal.

(*b*) *Hydrocele*

This is usually of "congenital" type. As the sac communicates with the peritoneal cavity through a small opening, the fluid can be slowly reduced.

(c) *Torsion*

This commonly affects the imperfectly descended testis although it may occur when free descent has taken place. The twist takes place inside the tunica vaginalis. The condition has an acute onset, closely resembling acute epididymo-orchitis or strangulated inguinal hernia. Atrophy or even gangrene of the testis may result. *Acute onset*

(d) *Inflammation*

An acute epididymo-orchitis occurring in a retained abdominal testis may initiate peritonitis.

(e) *Neoplasm*

In the imperfectly descended testis malignant tumours are ten times commoner than in the normally placed organ. If the testis is intra-abdominal the growth may escape detection for a considerable time. This is a strong argument against abdominal re-position of a testis if it proves impossible to place it in the scrotum.

5. SYMPTOMS

These are as a rule insignificant apart from those directly attributable to complications. After puberty pain may be troublesome.

6. DIAGNOSIS

In the child the absence of one or both testes from the scrotum has to be differentiated from intermittent retraction. In imperfect descent the corresponding side of the scrotum is undeveloped. The most important point to decide is whether the testis is merely arrested or is in fact ectopic and the characteristics of inguinal ectopic testis should particularly be borne in mind. Children should be examined carefully, gently and in a warm room. Hernia or hydrocele will give definite physical signs and are important as they indicate that the testis cannot be expected to descend fully without operation.

7. TREATMENT

In cases of ectopia or in cases of arrested descent with associated hernia or hydrocele, operation is the only rational treatment and for choice should be carried out at 5 years of age.

(1) Hormone therapy

This is suitable only for uncomplicated arrested descent and the exact timing of treatment is a matter of opinion. Smith and Engle (1934) proved that injection of anterior pituitary hormone produced a growth of the testis and also of the accessory glands and penis. This is an important point because it is undesirable to produce precocious puberty by excessive dosage if it is obvious that the testis is not likely to descend without operation. Gonadotrophic hormone from pregnancy urine produces similar effects. Schapiro in 1930 was the first to report clinical findings and used prolan in two cases with excellent results. Spence and Scowen (1935) produced normal descent in 9 out of 27 unilateral cases. *Growth of testis*

the external ring and turned upwards towards the anterior superior spine of the ilium. Such a testis usually preserves considerable mobility so that it can be pushed back into the dilated external ring.

(b) Pubic

In this case the testis lies at the root of the penis.

(c) Perineal

The testis passes to the outer side of the scrotum and comes to lie behind it.

(d) Femoral

The testis passes downwards into the femoral triangle.

(3) Pathological anatomy

The imperfectly descended testis is smaller than normal and has a well developed mesorchium joining it to the epididymis and parietal layer of the tunica vaginalis. In the majority of cases the processus vaginalis remains patent constituting a potential hernia and interfering with the normal descent of the testis. In addition there are fibrous bands in the cord which produce shortening. The vas and the vessels may also be relatively short preventing adequate mobilization of the testis. It may be possible to overcome this shortening by dissection of the cord bundle in the retroperitoneal tissue and by division of the deep epigastric artery.

Potential hernia

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tightly to prevent retraction of the testis, but without endangering its blood supply. The scrotal and inguinal incisions are now closed by sutures. In bilateral cases the operation is done in two stages at an interval of 6 months.

Keetley-Torek operation

In the Keetley-Torek operation a small incision, one and a half inches long, is made on the inner side of the thigh just below the inguinal ligament and parallel with it. An incision of equal length is made in the side of the scrotum. The posterior lip of the scrotal incision is sutured to the upper and inner lip of the thigh incision. By blunt dissection a bed is made in the deep fascia of the thigh. The testis is now drawn down through the scrotal wound and the suture in the bottom of the tunica vaginalis is secured to the deep fascia of the thigh. The anterior lip of the scrotal incision is sutured to the lower and outer lip of the incision in the thigh thus burying the testicle and cord in a cutaneous tunnel. After 6 months the scrotum and thigh are dissected free and the wounds closed by sutures, having first separated the testis from its attachment to the thigh.

Blunt dissection

(b) *Orchidectomy*

Orchidectomy is reserved for cases in which it is impossible to bring the testicle down at all or to bring it down only with excessive tension and with jeopardy to its blood supply. Orchidectomy is also necessary in cases of neoplasm and usually in torsion.

(c) *Abdominal replacement*

Abdominal replacement is very undesirable owing to the risks of malignant disease, torsion and infection. It may prove necessary in bilateral cases for which operation becomes imperative because of complications and orchidopexy proves impossible.

8. RESULTS

The Bevan operation only gives satisfactory results in 50 per cent of cases. The Turner-Ombredanne and Keetley-Torek operations give good results in 85–90 per cent of cases. A good result implies a normal sized testis lying free in the scrotum at the normal level with no tendency to retraction.

9. PROGNOSIS

Smith (1941) by his investigations has confirmed the chance of spontaneous descent occurring up to the time of puberty, that is to say approximately 12 years of age In bilateral cases, particularly those associated with obesity, descent at puberty is the rule while in unilateral cases it can be expected in 50 per cent of cases.

PART II

HYDROCELE

PAGE

In cases of arrested descent it is best to delay the use of hormone until the age of eight years. The chances of success are greater in bilateral cases and if the active principle of pregnancy urine is used, 500 international units should be injected once a week up to a total dose of 4,000 units. No further effect can be expected after this dose and success can be expected in about 40 per cent of cases. Even if not wholly successful, partial descent may render the prognosis of subsequent operation more hopeful by increasing the size of the testis. Hormone can also be used post-operatively when the testis is small and has been transplanted only with difficulty. As Cabot (1937) pointed out excessive dosage is fraught with real danger of atrophy of the testis.

Pregnancy urine

(2) Operative treatment

This covers several types of operation.

(a) Transplantation to the normal situation—orchidopexy.
(b) Orchidectomy.
(c) Abdominal re-position—orchidocoelioplasty.

(a) *Orchidopexy*

Age of patient

Orchidopexy may be performed between the ages of 5 years and puberty. Before the age of 5 years the operation is technically difficult and is to be undertaken only if complications force an issue. After puberty the longer the operation is delayed the less the chances of normal development and spermatogenesis. Three types of orchidopexy have been used (1) the Bevan operation, (2) the Turner-Ombredanne operation, and (3) the Keetley-Torek operation.

Initial phases

The initial phases of these three operations are identical and consist of an exposure of the testis and its liberation from all contracted bands and adhesions, in particular any rudiments of the processus vaginalis. Great care must be taken not to endanger the blood supply. An inguinal incision is made and the cord and testis exposed. The cord bundle is carefully dissected and the processus tied off at the internal abdominal ring. The lower part of the processus vaginalis is left with the testis. The vascular pedicle is mobilized by stripping it up in the extraperitoneal tissue. This will have the effect of lengthening the cord. The gubernacular bands at the lower pole of the testis are freed and divided. The empty half of the scrotum is dilated by pushing a finger downwards through the inguinal wound.

Exposure of cord and testis

Bevan operation

In the Bevan operation the testicle is secured in the scrotum by stitches or in addition a transfixion stitch is tied round an external splint for 10 days. The results are poor, as there is a great tendency for the testis to retract.

Turner-Ombredanne procedure

In the Turner-Ombredanne operation the median raphe of the scrotum is identified and a short incision made in front of the scrotum on the opposite side. A bed is prepared by blunt dissection between the septum and the inner side of the normal testis. A suture is passed through the lower end of the tunica vaginalis of the mobilized, imperfectly descended testis. The end of this stitch is gripped in forceps which are passed down through the inguinal incision to push against the scrotal septum, which is made to appear in the scrotal incision. A small incision is now made in the septum and the suture pulled through. Further traction on the stitch pulls the testicle and cord through the hole in the septum into the opposite scrotal compartment. The hole in the septum is now closed round the cord with sutures, sufficiently

in cases of tertiary syphilitic orchitis or of neoplasm of the testis. It is unusual for the hydrocele to be tense or large enough to mask the condition of the underlying testis.

4. PATHOLOGY

In acute hydrocele the fluid tends to disappear with the resolution of the exciting cause. In chronic hydrocele there may be gross thickening of both layers of the tunica vaginalis and adhesions may be present making the sac multilocular. The testis may be atrophic from pressure or from circulatory interference. The contained fluid is straw-coloured containing albumin, globulin and fibrinogen. It clots on the addition of tissue extract. In congenital hydrocele the fluid may be an expression of generalized peritoneal exudate, for example as occurs in tuberculous peritonitis.

5. SYMPTOMS AND SIGNS

In acute hydrocele the primary disease attracts attention. In chronic hydrocele the possibility of underlying disease should always be considered and if necessary the tunica aspirated to enable adequate palpation of the scrotal contents. Idiopathic chronic hydrocele produces dragging discomfort and mechanical inconvenience. On examination a fluctuant swelling which can be transilluminated is diagnostic. If the walls are grossly thickened transillumination may be difficult but can be elicited in a darkened room using a powerful light. If the hydrocele is of congenital type a feeble expansile impulse may be present and the swelling can be reduced if the patient lies down.

6. COMPLICATIONS

(i) *Rupture.*—Rupture following a blow on the scrotum results in an extravasation of fluid into the scrotal cellular tissue and a boggy swelling which pits on pressure making palpation of the testis difficult.

(ii) *Haemorrhage.*—Haemorrhage into the hydrocele sac following accidental trauma or aspiration produces a haematocele. The swelling becomes opaque and heavy to the hand on palpation.

7. DIFFERENTIAL DIAGNOSIS

(1) Hernia

In children a hernia may be translucent but gives a strong expansile impulse on coughing. A hernia is reducible and it is impossible to "get above" the swelling.

(2) Haematocele

Haematocele is opaque and feels heavy, the scrotum showing discoloration.

(3) Spermatocele

Usually this is thin walled and is felt above and distinct from the testis. The fluid obtained from a spermatocele by aspiration is opalescent and contains degenerate spermatozoa. Spermatoceles are often multiple and bilateral.

HYDROCELE—*continued.*

1. DEFINITION

Hydrocele denotes a collection of serous fluid in the tunica or processus vaginalis.

2. ANATOMY

The following anatomical types can be recognized.

(i) "*Congenital*" in which the processus vaginalis is patent but the communication with the peritoneal cavity is large enough only to permit the entry of fluid.

(ii) *Vaginal* in which the normally developed tunica is distended with fluid.

(iii) *Infantile* in which there is an upward prolongation of the tunica vaginalis pushing up towards the inguinal canal.

(iv) *Encysted hydrocele of the tunica vaginalis* in which only part of the sac of the tunica vaginalis is patent owing to adhesions between the visceral and parietal layers.

(v) *Abdominal or hour-glass hydrocele* in which a bilocular sac is present with a narrow isthmus passing up the inguinal canal and communicating with an expansion in the extraperitoneal tissues of the cave of Retzius. This abdominal portion may attain a very large size.

(vi) *Encysted hydrocele of the cord* due to a persistence of the central portion of the processus vaginalis.

3. AETIOLOGY

Hydrocele may be primary also termed *idiopathic that is to say* without obvious cause or secondary due to disease in the testis. Secondary hydroceles may be acute or chronic.

Idiopathic Idiopathic hydrocele is undoubtedly often associated with impaired venous or lymphatic drainage. Thus it may occur in cases of *inguinal hernia* of long standing or after operation for inguinal hernia. It is also commonly seen after the radical operation for the cure of varicocele.

Acute Acquired hydrocele is seen in association with acute and chronic epididymo-orchitis, due to non-specific infection or tuberculosis. Acute hydrocele may *Chronic* complicate mumps, typhoid fever or syphilis. Chronic hydrocele may occur

in cases of *tertiary syphilitic orchitis or of neoplasm of the testis*. It is unusual for the hydrocele to be tense or large enough to mask the condition of the underlying testis.

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8. TREATMENT

The conditions may be treated by tapping, by injection of sclerosing agents, or by radical operation.

(1) Tapping

Tapping a hydrocele may result in cure in a child but is purely palliative in the case of an adult.

Technique

The scrotum should be made tense and the position of the testis defined. An avascular area of the scrotal skin overlying the fluid is selected and a fine trocar and cannula driven into the sac. If a really fine trocar is used there is no need for a local anaesthetic and little chance of oozing of blood from the site of puncture. After removal of the cannula a dressing is unnecessary. It is advisable to fit a suspensory bandage after tapping.

(2) Injection of sclerosants

This form of treatment is not devoid of risk and is uncertain in its curative results. After aspiration with a trocar and cannula 2 millilitres of quinine and urethane are injected. The treatment is repeated at weekly intervals until obliteration is achieved.

(3) Operation

Two operations are commonly practised—excision of the sac and eversion of the sac.

(a) Excision of the sac

Seriatim division of layers

The scrotum is made tense and an incision made through the scrotal integuments over the lower part of the swelling. The various layers are divided seriatim, maintaining steady pressure until ultimately the clear serous layer of the tunica bulges into the wound. The tunica is secured and peeled away from the superficial layers until the point of attachment to the testis and epididymis is reached. Care must be taken to mobilize any upward prolongation of the tunica into the cord. Fluid is now removed completely and the tunica cut away from its attached margin. If there is oozing from the cut edge a running stitch of catgut is inserted. The operation is most easily carried out with diathermy dissection, including the actual incision of the scrotal skin. If there is any doubt about haemostasis a drain should be inserted into the dependent part of the wound.

Diathermy dissection

(b) Eversion of the sac (Jaboulay's operation)

The approach is the same but after a wide anterior incision of the tunica, the sac is turned inside out and the cut edges sutured with a continuous stitch behind the testicle and lowest portion of the cord. The wound should be drained.

Both excision and eversion can be carried out through an inguinal instead of a scrotal incision. More stripping of the sac is required and the tendency [illegible]

After the operation adequate scrotal support by a sling or suspensory bandage is desirable.

9. PROGNOSIS

In the congenital hydrocele of the infant it is common to meet with spontaneous cure. In adults the fluid tends to increase slowly rendering the sac tense. If the fluid is aspirated, it re-accumulates.

PART III

EPIDIDYMITIS

1. DEFINITION

Epididymitis implies a condition of inflammation of the epididymis as a result of bacterial invasion. There is a tendency for the inflammation to spread and involve the testis secondarily and therefore the term epididymo-orchitis is commonly used. *Bacterial invasion*

2. AETIOLOGY

The tube of the epididymis has various functions in that, while it is the duct through which the spermatozoa pass on to the vas, it is also a secretory organ, the secretions of which form a large part of the seminal fluid and it has, in addition, powers of excretion from the blood. This last function indicates that it can excrete organisms with or without obvious local lesions in the same manner as the kidney. *Functions*

3. ANATOMY

The epididymis receives an arterial blood supply apart from that to the testis and therefore it is possible to remove the epididymis without necessarily endangering the vitality of the testis. *Blood supply*

4. PATHOLOGY

Infection can reach the epididymis *via* the blood stream in which case the infection may originate in either the globus major or minor. Alternatively, infection may ascend the lumen of the vas from the posterior urethra and seminal vesicles in which case the globus minor is affected first.

Paths of infection

It has been shown experimentally that it is impossible to force fluid back along the vas beyond the globus minor, at which point it becomes arrested, never reaching as far as the body of the epididymis. There is no true reverse peristalsis, but distension of the vas owing to a blocked ejaculatory duct predisposes to epididymitis.

Distension of vas

Infection may be acute or chronic. Of the acute infections, 90 per cent are due to the gonococcus, the other organisms commonly found being *Bacillus coli*, streptococci and staphylococci. Of the chronic infections, 90 per cent are tuberculous. Whether the path of infection is haematogenous or ascending, the local changes are the same. The globus minor is the most common site of the initial lesion, which is interstitial as well as intratubular. Interstitial spread is the more important and the tubule tends to become occluded by peritubular fibrosis. It is difficult to produce chemical epididymitis except by using strong irritants, and this would appear to discredit the theory that non-specific epididymitis is produced by regurgitation of sterile urine into the normal ejaculatory duct during muscular exertion with a full bladder.

Acute infection

Chronic infection

Fibrosis

Erotic epididymitis is not a true inflammation as it subsides rapidly and is due to acute engorgement and distension from active secretion without sexual gratification; it might, however, predispose to bacterial invasion. If associated urethritis or vesiculitis are not present the infection is almost certainly haematogenous. Acute infections of the ascending type due to organisms other than the gonococcus are prone to progress to suppuration. There is a tendency for initial acute infections to relapse producing recurrent epididymitis.

Erotic epididymitis

In Reiter's disease, subacute urethritis, arthritis and conjunctivitis are found and the condition frequently relapses. Epididymitis may be associated.

Reiter's disease

5. CLINICAL FEATURES

(1) *Acute epididymitis*

The initial symptoms may be frequency of micturition with burning and occasionally with haematuria. Pain in the suprapubic region and in the groin is noted. Pain is felt in the epididymis and the scrotal integuments become swollen, red and tender on the posterior surface. An associated effusion occurs in the tunica vaginalis but this is not sufficient to mask the underlying condition. If urethral discharge has been present this subsides with the onset of epididymitis. Acute inflammation may resolve in 10 days, leaving an induration of the epididymis. In those cases which follow operation on the prostate and posterior urethra, suppuration usually occurs. Occasionally an acute onset is seen in cases of tuberculosis of the epididymis. In all cases

Pain

Suppuration

there is an associated funiculitis with generalized oedema of the cord, and there is thickening of the vas itself.

(2) Chronic epididymitis

Pain, if present, is usually insignificant, and the principal feature is that of a nodule at first discrete. If the infection is tuberculous the nodule enlarges and more of the epididymis becomes involved. The scrotal integuments over the nodule become adherent and the central part of the nodule softens. The overlying skin becomes dusky and finally ulcerates, producing a typical tuberculous sinus leading down to the indurated area. A lax hydrocele is present and the body of the testis becomes involved sooner or later. The cord as a whole is not enlarged but the vas is thickened and sometimes beaded in addition. In tuberculous epididymitis, the vesicle or vesicles are often found to be thickened, and nodules and fibrosis are felt in the prostate. *Tuberculous infection*

Chronic non-specific cases lead to persistent thickening and sometimes to severe pain.

6. DIFFERENTIAL DIAGNOSIS

(1) Acute cases

Gonorrhoea must be excluded as the most likely cause. Post-operative cases occur about the tenth day but can be avoided by division and ligation of the vas at the time of the operation. In cases due to an indwelling catheter, particularly in association with a spinal bladder, early suppuration will occur. Torsion of the testis may be confused with epididymitis but the pain is very severe and of sudden onset and is not relieved by local support. In so-called non-specific cases, a causative organism may be isolated from the urine or a sterile pyuria may be discovered. Metastatic cases are met with in influenza and meningitis. *Torsion*

(2) Chronic cases

The problem is to exclude tuberculosis and it should be remembered that occasionally a mixed infection is present. If the condition fails to resolve and is followed by slow enlargement of the epididymis with softening at the centre, tuberculosis should be diagnosed. Observation over a period of time is often the only way of arriving at a correct diagnosis, unless there are such obvious pointers as active tuberculosis in the urinary tract or in the lung, or gross changes are present in the seminal vesicles. Very rarely, a gummatous lesion is found in the epididymis but serological investigation should decide the diagnosis. Tumours and small tense cysts in relation to the upper part of the epididymis may give rise to difficulty, and so may torsion of the hydatid of Morgagni. Vascular diseases, such as thromboangiitis obliterans, may affect the pampiniform plexus, and the thrombosed veins may be mistaken for epididymitis. *Mixed infection*

7. TREATMENT

(1) Acute cases

Any local treatment to the urethra should be stopped immediately. Rest in bed, light diet and aperients are prescribed. Sulphonamide therapy is commenced and the scrotum supported by a sling. If suppuration occurs, *Sulphonamide therapy*

4. PATHOLOGY

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Distension of vas

Acute infection

Chronic infection

Infection may be acute or chronic. Of the acute infections, 90 per cent are due to the gonococcus, the other organisms commonly found being *Bacillus coli*, streptococci and staphylococci. Of the chronic infections, 90 per cent are tuberculous. Whether the path of infection is haematogenous or ascending, the local changes are the same. The globus minor is the most common site of the initial lesion, which is interstitial as well as intratubular. Interstitial spread is the more important and the tubule tends to become occluded by peritubular fibrosis. It is difficult to produce chemical epididymitis except by using strong irritants, and this would appear to discredit the theory that non-specific epididymitis is produced by regurgitation of sterile urine into the normal ejaculatory duct during muscular exertion with a full bladder.

Fibrosis

Erotic epididymitis

Erotic epididymitis is not a true inflammation as it subsides rapidly and is due to acute engorgement and distension from active secretion without sexual gratification, it might, however, predispose to bacterial invasion. If associated urethritis or vesiculitis are not present the infection is almost certainly haematogenous. Acute infections of the ascending type due to organisms other than the gonococcus are prone to progress to suppuration. There is a tendency for initial acute infections to relapse producing recurrent epididymitis.

Reiter's disease

In Reiter's disease, subacute urethritis, arthritis and conjunctivitis are found and the condition frequently relapses. Epididymitis may be associated.

5. CLINICAL FEATURES

(1) Acute epididymitis

Pain

The initial symptoms may be frequency of micturition with burning and occasionally with haematuria. Pain in the suprapubic region and in the groin is noted. Pain is felt in the epididymis and the scrotal integuments become swollen, red and tender on the posterior surface. An associated effusion occurs in the tunica vaginalis but this is not sufficient to mask the underlying condition. If urethral discharge has been present this subsides with the onset of epididymitis. Acute inflammation may resolve in 10 days, leaving an induration of the epididymis In those cases which follow operation on the prostate and posterior urethra, suppuration usually occurs. Occasionally an acute onset is seen in cases of tuberculosis of the epididymis. In all cases

Suppuration

there is an associated funiculitis with generalized oedema of the cord, and there is thickening of the vas itself.

(2) Chronic epididymitis

Pain, if present, is usually insignificant, and the principal feature is that of a nodule at first discrete. If the infection is tuberculous the nodule enlarges and more of the epididymis becomes involved. The scrotal integuments over the nodule become adherent and the central part of the nodule softens. The overlying skin becomes dusky and finally ulcerates, producing a typical tuberculous sinus leading down to the indurated area. A lax hydrocele is present and the body of the testis becomes involved sooner or later. The cord as a whole is not enlarged but the vas is thickened and sometimes beaded in addition. In tuberculous epididymitis, the vesicle or vesicles are often found to be thickened, and nodules and fibrosis are felt in the prostate. *Tuberculous infection*

Chronic non-specific cases lead to persistent thickening and sometimes to severe pain.

6. DIFFERENTIAL DIAGNOSIS

(1) Acute cases

Gonorrhoea must be excluded as the most likely cause. Post-operative cases occur about the tenth day but can be avoided by division and ligation of the vas at the time of the operation. In cases due to an indwelling catheter, particularly in association with a spinal bladder, early suppuration will occur. Torsion of the testis may be confused with epididymitis but the pain is very severe and of sudden onset and is not relieved by local support. In so-called non-specific cases, a causative organism may be isolated from the urine or a sterile pyuria may be discovered. Metastatic cases are met with in influenza and meningitis. *Torsion*

(2) Chronic cases

The problem is to exclude tuberculosis and it should be remembered that occasionally a mixed infection is present. If the condition fails to resolve and is followed by slow enlargement of the epididymis with softening at the centre, tuberculosis should be diagnosed. Observation over a period of time is often the only way of arriving at a correct diagnosis, unless there are such obvious pointers as active tuberculosis in the urinary tract or in the lung, or gross changes are present in the seminal vesicles. Very rarely, a gummatous lesion is found in the epididymis but serological investigation should decide the diagnosis. Tumours and small tense cysts in relation to the upper part of the epididymis may give rise to difficulty, and so may torsion of the hydatid of Morgagni. Vascular diseases, such as thromboangiitis obliterans, may affect the pampiniform plexus, and the thrombosed veins may be mistaken for epididymitis. *Mixed infection*

7. TREATMENT

(1) Acute cases

Any local treatment to the urethra should be stopped immediately. Rest in bed, light diet and aperients are prescribed. Sulphonamide therapy is commenced and the scrotum supported by a sling. If suppuration occurs, *Sulphonamide therapy*

prompt incision should be made to avoid undue damage to the testis. In relapsing cases, vasectomy or even epididymectomy may be necessary.

(2) Chronic cases

In cases of tuberculosis, once the diagnosis has been established, epididymectomy should be performed, unless the disease has progressed to involve the body of the testis, in which case orchidectomy must be carried out. The vas should be divided at the internal abdominal ring. Radical removal of the seminal tract as advocated by Young (1935) gives no better results, and is fraught with grave surgical risks of damage to the bladder and rectum. After the removal of a tuberculous epididymis, the corresponding vesicle usually fibroses or even calcifies.

If the vesicles and prostate are obviously involved it is best to divide and ligate the vas on the sound side to minimize the risk of spread to the remaining epididymis and testis, but when the vesicles and prostate appear normal it is better not to divide the vas on the sound side as there is always the possibility of the patient remaining fertile.

Finally, operation is only part of the treatment, and a period of rest or even sanatorium treatment for a time may be necessary.

If resistance to tuberculosis appears to be low streptomycin should be given.

8. TECHNIQUE OF EPIDIDYMECTOMY

This depends on whether attachment of the epididymis to the scrotal integuments has occurred or not. In the latter case an inguinal incision is made and the testicle is drawn up into the wound after dividing the coverings of the cord The vas deferens is dissected from the cord bundle and divided at the internal ring, the ends being cauterized. The tunica vaginalis is opened and the lower end of the vas followed down to the globus minor of the epididymis, which is dissected from the lower pole of the testis. The vascular pedicle to the upper pole of the testis is then carefully identified and the rest of the epididymis removed. It is easiest to carry out the operation by diathermy dissection. If the scrotal integuments are adherent, an ellipse of skin embracing the involved area is dissected free and the incision carried up to the inguinal region, completing the operation in the usual manner.

Diathermy dissection

9. POST-OPERATIVE CARE

In tuberculosis any operation is only a part of the treatment and rest and fresh air should be insisted upon for a time. Bacillary emulsion and tuberculin are of doubtful value (O'Neil and Hawes, 1913).

Results.—Forty per cent of cases of tuberculous epididymitis are cured of disease in the genital tract by operation.

PART IV

NEW GROWTHS OF TESTIS AND EPIDIDYMIS

1. DESCRIPTION

New growths include neoplasms of the testes and their coverings. Of these, neoplasms of the epididymis and tunica vaginalis are relatively very rare.

2. AETIOLOGY

Attempts to show that testicular neoplasia may have been initiated by trauma are constantly made but there is no valid evidence to this effect. A most important fact is that neoplasms are ten times commoner in the retained *Neoplasms* or imperfectly descended testis than in the normal testis. The majority of examples of testicular new growth occur in the period of active sexual function. Bilateral tumours form 1 per cent of the recorded cases.

3. SURGICAL ANATOMY

The testis derives its blood supply from its abdominal cradle in the pre-aortic area and its lymphatic drainage is correspondingly to the pre-aortic glands.

4. PATHOLOGY

The majority of testicular tumours are malignant and highly malignant, although their sinister reputation is probably somewhat exaggerated. As a group, they form only 0·58 per cent of all malignant tumours in the male.

(1) Benign tumours

Benign tumours of the testis are extremely rare and may be fibroma, lipoma or myxoma. Benign tumours of the epididymis are commoner than of the testis, consisting of leiomyoma, lymphangioma, angioma and adenoma.

As a whole, benign tumours can be dismissed as unimportant in that their true nature will be discovered only on microscopy subsequent to their removal on the justifiable assumption of malignancy.

(2) Malignant tumours

Malignant tumours of the testis are seminoma, teratoma and interstitial-cell tumours. Malignant tumours *of the epididymis* may be either sarcoma or carcinoma.

Seminoma

Seminoma, so termed first by Chevassu, or spermatocytoma, arises from the germinal epithelium of the seminiferous tubules and is usually solid and creamy coloured The average age of onset is 39 years

Teratoma

In teratoma, all the tissues may be represented, although frequently one predominates. Thus, cases are met with resembling chorion-epithelioma; in others, the various tissues may be highly differentiated as in the type termed fibro-cystic disease of the testis. The average age of onset is 29 years.

Testicular tumours

Malignant testicular tumours spread both by the lymphatics and by the blood stream. Thus, involvement of the pre-aortic glands and pulmonary metastases are common. Sections of the spermatic cord frequently show deposits of growth in the course of the vessels and palpable nodules may be detected on clinical examination.

Gonadotrophic hormone

A distinctive feature in malignant testicular tumours is the presence in the urine of gonadotrophic hormone of pituitary or chorionic origin. The amount and nature of this substance present gives some idea of the histology of the tumour and also indicates its response to treatment. Thus, a return of demonstrable quantities of gonadotrophic hormone after operation denotes the development of metastases. Generally speaking, the more malignant the tumour, the greater the amount present; chorion-epithelioma may produce as much as 50,000 or more mouse units of chorionic gonadotrophin per litre of urine. After removal of the tumour, the test becomes negative in a fortnight If a tumour is radio-sensitive, x-ray treatment will produce a diminution in the amount present.

Interstitial-cell tumours

Interstitial-cell tumours are relatively rare and tend to occur in childhood, being associated with sexual precocity.

5. CLINICAL FEATURES

The characteristic initial feature is the insidious development of a swelling in the testis. Pain is not a prominent feature unless the tumour is of very rapid growth Usually, loss of testicular sensation develops. The swelling gives the clinical sense of heaviness, and, in the early stages, the epididymis can be distinguished on the back of the swelling. Tumours in the rete testis may give rise to great difficulty in diagnosis. A slack hydrocele may be present but not of sufficient size to mask the underlying testis. On aspiration, the hydrocele fluid may contain blood or malignant cells. Congestion of the overlying scrotal tissues may be noted but fungation through the scrotum is extremely rare.

Loss of sensation

Tumour in rete testis

[illegible] tumours often [illegible] a [illegible] golden rule always to examine the scrotal contents in any [illegible] an obscure neoplasm possibly of metastatic origin.

The commoner metastases are as follows:

Metastases

[illegible] as an obscure retro- [illegible]

(ii) *Pulmonary metastases*, especially common in teratoma. They are of "cannon-ball" type and may produce dyspnoea, pain and asthenia.

(iii) *Diffuse glandular metastases.*

Sexual precocity may be met with in infants with interstitial-cell tumours.

Gynaecomasty should always arouse suspicion of a testicular neoplasm; the breast enlargement may be present on one side only. *Gynaecomasty*

6. DIAGNOSIS

Examination of the urine may reveal the presence of hormone, thus establishing the diagnosis, but a negative test is of no significance. The hormone may be of two types, in teratoma being chorionic and in seminoma being hypophyseal. The investigation is also helpful in establishing prognosis, as the teratoma is relatively radio-resistant, whereas the seminoma is highly radiosensitive. *Types of hormone*

Absence of one or both testicles from the scrotum, with the presence of a tumour in the course of testicular descent, is diagnostic.

Differential diagnosis

Haematocele may give rise to difficulty in diagnosis, particularly when there is no evidence of a pre-existing hydrocele. Gumma is usually softer, lighter and associated with positive serological tests. Simple tumours cannot be differentiated from malignant tumours unless removal and subsequent microscopy is carried out. Localized epididymal swellings also may call for exploration to establish the diagnosis. *Haematocele* *Gumma* *Simple tumours* *Epididymal swellings*

7. TREATMENT

Orchidectomy, followed by radiotherapy, is the correct treatment. Orchidectomy includes a removal of the spermatic cord up to the level of the internal abdominal ring. Radical operation, continuing the incision upwards and dissecting the vascular pedicle up to the aorta, has nothing to offer to offset against the added severity of the operation. The abdominal field can be dealt with better by post-operative radiotherapy. Radiotherapy alone is undesirable, as it subjects the patient to considerable toxic absorption of breakdown products. Radiotherapy should be carried out with x-ray radiation, treatment involving the pelvis, inguinal region and lumbar glands on both sides. *Orchidectomy*

A difficulty arises in the case of the well-differentiated teratoma as in fibrocystic disease. Potentially this is a highly malignant totipotent cellular tumour, which may disseminate and may prove radio-sensitive. It is therefore best to treat it in the same way as other testicular tumours.

In a series of 24 cases of seminoma treated at the Middlesex Hospital by Gordon-Taylor and Till (1938), 50 per cent were alive 5 years afterwards. Figures from the Mayo Clinic show that 47·4 per cent of seminoma cases and 26·4 per cent of teratoma cases were alive 10 years after treatment. Gordon-Taylor and Wyndham (1947) reported 636 cases. These showed a 76 per cent mortality after 10 years, the cases of teratoma being more malignant than those of seminoma.

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TETANUS

By J. S. K. BOYD, O.B.E., M.D., D.P.H.

Director, Wellcome Laboratories of Tropical Medicine, London

1. DEFINITION

321.] Tetanus is a disease caused by the toxin of *Clostridium tetani*, an anaerobic bacillus of saprophytic habits which may contaminate wounds and develop in dead tissue present in their depths. The characteristic symptom is a spasm of voluntary muscle, which usually starts in the jaw or neck and spreads thence to the rest of the body. The general picture is one of recurring paroxysms of violent muscular contractions superimposed on a background of tonic rigidity.

Spasm of voluntary muscle

2. BACTERIOLOGY AND IMMUNOLOGY

Clostridium tetani is a Gram-positive, motile bacillus which forms round terminal spores. It belongs to the proteolytic group of anaerobes, and it can be identified either serologically—there are at least 8 antigenic types—or by the action of its toxin on experimental animals. The spores are highly resistant to antiseptics and heat and can withstand boiling for 5 minutes.

The tetanus bacillus

The normal habitat of the tetanus bacillus is in the large intestine of man and various lower animals, including horses and cattle. In this environment it is non-pathogenic. The spores are voided in the faeces and, under natural conditions, become mixed into the soil and remain viable for long periods of time. They have an almost ubiquitous distribution but are more common

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Delayed tetanus results from a secondary operation or from manipulation which reactivates spores lying dormant in the depths of the primary wound. It occurs if the administration of prophylactic antitoxin at the time of the original lesion has prevented the development of an overt attack. *Delayed tetanus*

4. CLINICAL PICTURE

In the absence of prophylactic immunization, symptoms of tetanus usually appear about the eighth day after infection is incurred. Exceptionally, the first signs may be seen on the second day, or the onset may be delayed for some weeks. Such delay is usually associated with passive immunization. *Incubation period*

(1) Tonic spasm and trismus

Spasticity of the muscles round the wound may be the earliest symptom and is an important danger signal. As a rule, trismus is the first reliable indication of tetanus infection to develop, and may become so severe that it is impossible to force open the patient's mouth. Trismus may be accompanied by spasm of the facial muscles, the so-called "risus sardonicus", and as the disease advances, stiffness of the neck becomes intense, causing retraction of the head, and the spasm spreads to the trunk. The abdomen becomes rigid and the back arches to produce the characteristic posture of opisthotonos. Finally, the limbs are affected. They are usually fixed in extension but occasionally the knees and elbows may be flexed. The hands commonly escape. *"Risus sardonicus"*

Additional to this continuous tonic spasm are violent recurring reflex spasms, accompanied by agonizing pain, in which all the muscles contract to a board-like hardness. These paroxysms may be precipitated by trivial stimuli such as sudden light, noise, heat or cold, but frequently they occur without any obvious cause *Recurring reflex paroxysms*

The temperature is usually raised a few degrees and sweating may be profuse, particularly during the paroxysms. The pulse is rapid and weak. *Temperature and pulse*

In cases which run a favourable course, the paroxysms, if present, decrease in frequency and finally cease, while the tonic spasm lessens. The latter may, however, persist for a considerable time and it may be weeks before the patient, who otherwise appears well, is able to open his mouth freely. *Further progress*

In fatal cases, paroxysms become more severe and frequent, and death results either from exhaustion or from involvement of the respiratory muscles. *Fatal cases*

(2) Local tetanus

Local tetanus is confined to the muscles in the immediate proximity of the infected wound. It varies in severity from a painful twitching to an intense degree of contraction which may persist for long periods It is caused by failure of the prophylactic antitoxin to reach, and to neutralize, the toxin in the tissues round the wound In consequence, absorption occurs from this site and produces lesions in the corresponding motor nerve cells

The term cephalic or head tetanus is applied to infection resulting from head or facial injuries in which spasms are confined to the muscles of this region. A high percentage of such cases (75 per cent in one series) develop facial paralysis and in some the third, fourth and fifth cranial nerves are also affected (Anschutz, 1942). *Cephalic or head tetanus*

in rural surroundings and particularly in agricultural soil which has been manured. Being resistant to desiccation, they may be blown about in dust and are, in consequence, important potential contaminants of surgical dressings and instruments.

Conditions governing germination of spores

Outside their normal habitat spores will germinate, and the resulting vegetative organisms will multiply in wounds of all kinds, provided conditions of anaerobiasis are present. Such conditions are to be found in deeply seated blood clot, in areas of necrosis, particularly in the vicinity of a foreign body, and in lesions devitalized by an inadequate blood supply or by the action of pyogenic bacteria. Conversely, in an open and well-drained wound no development will take place.

Toxin

Clostridium tetani elaborates a potent exotoxin which diffuses into the surrounding tissues and is carried off by the blood stream. Though controversy exists as to the route which the toxin follows to reach the central nervous system, the balance of evidence favours the conclusion that it is absorbed by the end-plates of the motor nerves—both in the immediate proximity of the wound and in the more distant sites which it reaches *via* the blood stream—and thereafter it travels slowly along the nerve fibres to the cells of the central nervous system, on which it acts to produce the muscular spasm characteristic of the disease.

Antigenic properties of toxin

Tetanus toxin has the properties of an antigen and, when inoculated into experimental animals, it stimulates the formation of antitoxin. Pure fresh toxin is unsuitable for immunization purposes because of the dangerous symptoms which may be produced, even by minute doses. Its toxic properties can, however, be destroyed in various ways without reducing the antigenic action. The process most commonly employed for this purpose is to incubate the toxin with formalin for some weeks. The resultant product, which is known as formol toxoid or, more simply, toxoid, can be injected in relatively large quantities without causing symptoms. It is a powerful immunizing agent and is used both for the production of therapeutic antitoxin and for active immunization.

Toxoid

Antitoxin

Antitoxin is now standardized in international units which are one-half the potency of the original unit. Thus the 1,500-unit dose of World War I is equivalent to the 3,000-unit dose which is now given.

3. AETIOLOGY

Infection of wounds

Tetanus most frequently occurs as a sequel to the implantation of spores in a wound or abrasion, to which they are carried by the implement or missile which caused the wound, or by foreign bodies such as splinters of wood, fragments of clothing or particles of soil. Infection is related less to the severity of the wound than to its nature. The trivial puncture which is overlooked is a greater danger than the severe laceration which receives the surgeon's full attention.

Other sources of infection

Other occasional sources of tetanus are spore-infected catgut, hypodermic injections (particularly of necrotizing substances such as quinine), dressings and unsterilized dusting powder. The two last-mentioned are the usual cause of tetanus neonatorum, a condition arising from infection of the umbilical cord in young infants.

after the first. This interval can be increased without detriment to the subsequent level of immunity, but it should not be shortened. A third dose, 6 months or more later, enhances protection even further, and "recall" or "booster" doses at yearly intervals are employed to ensure a high and continuing level of immunity.

Active immunization has many advantages over passive immunization. As evidenced by the figures of World War II, it appears to afford more certain protection (Boyd, 1946). It avoids the discomfort and inconveniences of repeated antitoxin injections. It safeguards the trivial abrasion or wound for which antitoxin might wrongly be deemed unnecessary and eliminates the hidden danger of delayed tetanus. *Better protection*

(3) Combined immunization

In all actively immunized cases, if there is considerable risk of infection or if the patient is badly shocked, it is a wise precaution to give a single dose of 3,000 units of antitoxin. This will augment, for about 10 days, the basic level of circulating antitoxin derived from the previous active immunization. Thereafter, should the wound be tetanus-infected, an increasing concentration of antitoxin will appear in the blood as a result of the stimulation of the immunized reticulo-endothelial cells by the toxin absorbed from the wound.

8. TREATMENT

(1) General measures

The patient should be nursed in a darkened, quiet room and guarded as far as possible from all external stimuli. Adequate nourishment should be given, if necessary by nasal tube. Oxygen should be at hand to relieve cyanosis if this occurs as the result of prolonged spasm.

(2) Antitoxins

The first step in the treatment of tetanus is to administer a large dose of antitoxin. This should amount to 200,000 international units, except in the less severe type of case seen for the first time at a late stage, when half this dose will suffice (Cole, 1940) It is essential that the antitoxin should exercise its protective action with the least possible delay and, for this reason, it should be given intravenously. The intramuscular route is slower and less satisfactory and should be used only when intravenous injection is impracticable or is contra-indicated by a history of asthma or other allergic conditions. Though there is some experimental laboratory evidence in favour of the intrathecal route (Firor, 1940), and though intracisternal administration is practised in certain countries (Stern, 1943), the consensus of opinion is that there is more danger in giving antitoxin by these routes than there is benefit to be gained (Wainwright, 1926; Spaeth, 1941). *Contra-indications to intravenous route*

It is rare for further antitoxin to be necessary if other measures of treatment are carefully carried out. If reflex spasm persists, a dose of 50,000 units may be given in a week and, if necessary, repeated at 7-day intervals. If the patient is not actively immunized, prophylactic antitoxin must be given before any subsequent operation is undertaken. *Reflex spasm*

5. SPECIAL AIDS TO DIAGNOSIS

There is no laboratory test capable of giving timely and reliable confirmation of the diagnosis of tetanus, which must therefore rest on a critical appraisement of signs and symptoms. The examination of stained smears from the wound may reveal "drumstick" bacilli, but as other relatively unimportant clostridia have very similar morphological characters, this finding is not conclusive. It is unjustifiable to delay treatment until tetanus bacilli have been isolated and specifically identified.

6. DIFFERENTIAL DIAGNOSIS

Strychnine poisoning

Strychnine poisoning gives rise to symptoms which may bear a strong resemblance to those in tetanus. As a rule, the history and circumstances of the case will differentiate between the two conditions. In strychnine poisoning there is muscular relaxation between the recurring paroxysms, whereas in tetanus, tonic spasm is continuous. The body temperature is not raised in strychnine poisoning.

Rabies

Rabies is also characterized by reflex spasms with intervening relaxation. There is no trismus and the spasms affect chiefly the muscles of deglutition and respiration. Attempts to drink—even the sight of water—initiate paroxysms and produce the so-called hydrophobia.

Tetany

Tetany can be distinguished by the characteristic deformity it causes in the hands and feet, and by the history of the case.

Local lesions

Hysteria and stiffness of the jaw and neck resulting from local lesions may, on occasion, need to be differentiated but should present little difficulty.

7. PROPHYLAXIS

(1) Passive immunization

Casualties suffering from abr[illegible] by the subcutaneous or intram[illegible] international units suffices to [illegible] for a period of 7–10 days. In course of time, this antitoxin is either destroyed or excreted, and if the risk of infection is considerable as, for example, in wounds heavily contaminated with garden soil, it is advisable to repeat administration at weekly intervals until a total of 4 doses has been giv[en]. Should an interval of 24 hours or more have elapsed from the time whe[n] potentially infected wound was received, the first dose of antitoxin sho[uld] be increased 2 or 3 times. Such treatment will confer protection in all [but] the most exceptional cases.

Disadvantage

The main drawback to passive immunization is the risk of subsequ[ent] serum sickness. At one time a serious consideration, this complication is n[ow] rare and usually relatively mild when the concentrated and refined antito[xin] now available is used.

(2) Active immunization

Active immunization is carried out on those who are likely to be expos[ed] to infection because of their occupation, such as military personnel, agri-cultural workers, gardeners and grooms. Tetanus toxoid is administered

Dosage

2 doses of 1 cubic centimetre, the second dose being given at least 6 wee[ks]

after the first. This interval can be increased without detriment to the subsequent level of immunity, but it should not be shortened. A third dose, 6 months or more later, enhances protection even further, and "recall" or "booster" doses at yearly intervals are employed to ensure a high and continuing level of immunity.

Active immunization has many advantages over passive immunization. As evidenced by the figures of World War II, it appears to afford more certain protection (Boyd, 1946) It avoids the discomfort and inconveniences of repeated antitoxin injections. It safeguards the trivial abrasion or wound for which antitoxin might wrongly be deemed unnecessary and eliminates the hidden danger of delayed tetanus. *Better protection*

(3) Combined immunization

In all actively immunized cases, if there is considerable risk of infection or if the patient is badly shocked, it is a wise precaution to give a single dose of 3,000 units of antitoxin. This will augment, for about 10 days, the basic level of circulating antitoxin derived from the previous active immunization. Thereafter, should the wound be tetanus-infected, an increasing concentration of antitoxin will appear in the blood as a result of the stimulation of the immunized reticulo-endothelial cells by the toxin absorbed from the wound.

8. TREATMENT

(1) General measures

The patient should be nursed in a darkened, quiet room and guarded as far as possible from all external stimuli. Adequate nourishment should be given, if necessary by nasal tube. Oxygen should be at hand to relieve cyanosis if this occurs as the result of prolonged spasm.

(2) Antitoxins

The first step in the treatment of tetanus is to administer a large dose of antitoxin. This should amount to 200,000 international units, except in the less severe type of case seen for the first time at a late stage, when half this dose will suffice (Cole, 1940). It is essential that the antitoxin should exercise its protective action with the least possible delay and, for this reason, it should be given intravenously. The intramuscular route is slower and less satisfactory and should be used only when intravenous injection is impracticable or is contra-indicated by a history of asthma or other allergic conditions. Though there is some experimental laboratory evidence in favour of the intrathecal route (Firor, 1940), and though intracisternal administration is practised in certain countries (Stern, 1943), the consensus of opinion is that there is more danger in giving antitoxin by these routes than there is benefit to be gained (Wainwright, 1926; Spaeth, 1941). *Contra-indications to intravenous route*

It is rare for further antitoxin to be necessary if other measures of treatment are carefully carried out. If reflex spasm persists, a dose of 50,000 units may be given in a week and, if necessary, repeated at 7-day intervals. If the patient is not actively immunized, prophylactic antitoxin must be given before any subsequent operation is undertaken. *Reflex spasm*

(3) Surgical treatment

An hour after the administration of antitoxin the infected wound should be widely opened and cleaned to its depths, special attention being paid to pockets, and a careful examination being made for foreign bodies of any kind. All blood clot and dead tissues, particularly devitalized muscle, should be carefully removed. A search should also be made for smaller and less conspicuous wounds or abrasions which may previously have been overlooked. Free drainage of all wounds should be established to eliminate the anaerobic conditions necessary for the multiplication of tetanus bacilli, and, if necessary, irrigation with hydrogen peroxide should be carried out and repeated at intervals.

Drainage

Irrigation

(4) Sedatives

If reflex paroxysms have not developed, large doses of a bromide may be given to maintain a restful state. When such spasms are occurring, some control may be achieved by giving, per rectum, paraldehyde in doses of ½–1 drachm per stone of body-weight, or bromethol in quantities of 0·1 cubic centimetre per kilogram of body-weight and repeating as indicated by the symptoms. Hexobarbitone is useful for controlling sudden acute spasm, and any sedative or narcotic may be used in an emergency. It may be necessary to give a sedative prior to feeding or using a bed-pan.

Control of spasms

(5) Curare and Myanesin

Curare (Cole, 1934) and more recently *d*-tubocurarine chloride, a preparation which enables an exact dose of the active principle to be administered (Prescott, Organe and Rowbotham, 1946, Sears, 1947; Evans and Whiting, 1948), have been used with some success in relieving pain and in controlling or even abolishing spasm. In therapeutic doses tubocurarine exerts a blocking effect on the transmission of the nervous impulses at the myoneural junction of voluntary muscle and there is, therefore, a risk of producing respiratory paralysis. For this reason it is essential that facilities for artificial respiration

Respiratory paralysis

per stone of body-weight, injected intravenously. Given thus, its action p[illegible] off in about 30 minutes, and repeated doses should be given as necessary. Alternatively, intramuscular injections of 7·5 milligrams every 2 hours have been found to afford considerable relief of symptoms without producing paralysis.

Myanesin, which acts on the synapses in the spinal cord and possibly, though this is controversial, on the basal ganglia, has a similar action in relieving pain and spasm and has been found to do so at a dosage level which involves little or no risk of respiratory failure (Belfrage, 1947; Torrens, Edwards and Wood, 1948, Davison, Ward and Pask, 1949) It is given intramuscularly in doses of 0·5–1·0 gramme (5–10 millilitres of a 10 per cent solutic [illegible] ntramuscular
blood [illegible] ich
[illegible] ble
as tetanus, it may be necessary to regard this complication as [illegible]
risk.

Blood destruction and haemoglobinuria

9. RESULTS OF TREATMENT

It is possible, with the massive dose of antitoxin recommended, to n
all circulating toxin and, by the surgical toilet of the wound or wou
remove the infected focus from which toxin is emanating and so
any further absorption from taking place. The patient's fate then turns
degree of damage which has been done to the nerve cells by toxin whi
already reached them. If, in spite of active treatment, the spasm cont
the paroxysms increase in frequency and the temperature and pulse-rat
it is obvious that no improvement can be expected. If, however, s
diminishes and the paroxysms become less frequent and less severe, the
good reason to hope that the neutralization of the toxin and the preven
of further toxin formation has achieved its object and that the patient is
the way to recovery.

10. COMPLICATIONS AND PROGNOSIS

(1) Complications

Pneumonia is a common and dangerous complication, and every car
should be exercised to avoid its onset.

(2) Prognosis

Approximately 50 per cent of all tetanus infections are fatal, but this figure varies in different types of case.

When the incubation period is short (that is, less than 8 days) the disease usually runs an acute course with a high death-rate, whereas when the symptoms make a delayed appearance they are commonly less severe and the ultimate prognosis is better. This late onset generally results from temporary or partial protection conferred by passive immunization.

When trismus is the first symptom to appear and if, within 24 hours, the jaw is fixed so firmly that it cannot be opened, the outlook is grave; approximately 75 per cent of such cases are fatal. If complete closure of the mouth is delayed for more than 24 hours after the onset of trismus, or if the closure is only partial, the prognosis is less serious. When generalized symptoms occur before the onset of trismus or when trismus is completely absent, the chance of survival is even greater (Bruce, 1920–21).

High temperature, a rising pulse-rate and a shortening of the interval between paroxysms are all signs of serious import.

Local tetanus, exclusive of the cephalic type, is rarely, if ever, fatal.

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[References to other titles are given under Tetanus in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 12, p. 1.]

TETANY

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1. DEFINITION

322.] Tetany is a state of increased excitability of nerves so that slight or even normal stimuli may cause muscle spasm. Tetany may be latent when special tests are necessary to produce the spasms, or manifest, when spontaneous muscular spasms occur. *Latent* *Manifest*

2. PHYSIOLOGY

The increased excitability of the nerves is due to a diminution of the physiologically active calcium in the plasma. Calcium is present in the blood in three forms: in simple physical solution, in super-saturation, depending on the presence of parathormone, and in combination with plasma proteins, this fraction being physiologically inactive. The amount of active calcium in the blood may be diminished if there is reduction of the parathyroid secretion or if calcium absorption from the intestine is decreased. An increase in plasma phosphate causes a reduction of plasma calcium, as their concentration varies inversely. Active calcium may be neutralized by the presence of citrates given by transfusion. A change in the *p*H of the blood causing alkalaemia also reduces the physiological activity of the calcium ions. *Active calcium* *Alkalaemia*

3. CLINICAL PICTURE

With frank tetany there are spontaneous manifestations of neuro-muscular irritability, causing painful cramp, particularly in the hands and feet but sometimes involving the muscles of the face, neck and trunk.

Carpal spasm

Carpal spasm is particularly characteristic. The extended fingers are slightly flexed at the metacarpo-phalangeal joints and are bunched closely together with the extended thumb clamped into the palm. The wrists are flexed and the hand is drawn to the ulnar side.

There may be similar spasms of the feet. These spasms may be preceded by a sense of numbness, by pins and needles and are often associated with intense pain. Laryngeal spasm occurs particularly in children, producing a sudden onset of stridor and respiratory distress.

Laryngeal spasm

Chronic cases

In chronic cases the symptoms may be protean in their manifestations The nails become brittle and ridged and there is loss of hair. Dimness of vision and even blindness may be caused by cataract. Asthmatic manifestations may be due to bronchospasm. Mental irritability may develop and migraine and epilepsy are occasionally evident. Painful abdominal symptoms may be due to gastric or intestinal spasms and an acute abdomen may be simulated.

Clinical tests

Without frank symptoms latent tetany may be demonstrated by tests revealing neuro-muscular mechanism excitability.

(i) *Chvostek's sign.*—Hyperexcitability of the facial nerve is elicited by tapping over it immediately anterior to the external auditory meatus, when a muscular twitch is observed on that side of the face.

(ii) *Trousseau's sign.*—If the circulation in the arm is stopped by inflating a sphygmomanometer, the hand will go into carpal spasm.

Irritability of other nerves may be demonstrated. There may be dimpling of the tongue produced by light tapping. Tension on the sciatic nerve from flexing the thigh may cause spasm of the extensor muscles of the knee and plantar flexion of the foot.

4. AIDS TO DIAGNOSIS

(a) Erb's phenomenon

The increased excitability of the nerves is recorded by measuring the current necessary to stimulate a peripheral nerve, usually the peroneal or median. A cathodal opening contraction with a current of less than 5 milliamperes is highly suggestive of tetany.

(b) Serum calcium

This is usually below the normal value (10 milligrams per 100 millilitres), for example 6 milligrams, and the plasma phosphorus is above the normal (3·5 milligrams per 100 millilitres), for example 7 milligrams.

5. DIFFERENTIAL DIAGNOSIS

Causes of tetany

The causes of tetany may be classified as follows. (1) Tetany due to reduction in concentration of serum calcium: (a) hypoparathyroid tetany; (b) rickets; (c) osteomalacia; (d) steatorrhoea, and (e) pregnancy. (2) Tetany due to inactivation of ionized serum calcium. (a) citrate tetany; (b) phosphate tetany; and (c) alkalaemia. (3) Tetany associated with infectious diseases and other conditions.

(a) Hypoparathyroid tetany

Hypoparathyroid tetany occurs post-operatively, after the removal of a parathyroid tumour which has depressed the metabolic activity of the remaining glands. Post-operative tetany may also follow the accidental removal of the parathyroid glands with thyroidectomy. There is also an idiopathic form of hypoparathyroidism (comparable to idiopathic hypothyroidism).

(b) Rickets

Tetany with rickets may occur in the absence of gross clinical manifestations. An increased serum phosphatase would confirm the diagnosis.

(c) Osteomalacia

Osteomalacia in adults, due to lack of vitamin D and calcium, occurs under conditions of long-standing undernourishment and tetany may supervene, particularly in the winter months, in subjects whose work denies them access to sunlight.

(d) Steatorrhoea

Tetany with steatorrhoea occurs in coeliac disease of children, and in tropical or non-tropical sprue; it results from the diminished absorption of calcium by precipitation of insoluble calcium soaps in the intestine and also from inadequate absorption of vitamin D.

(e) Pregnancy

In pregnancy, there is an increased demand for calcium and vitamin D, but only very rarely does the calcium fall below normal limits, causing tingling, burning sensations in the extremities, muscle cramps and signs of latent tetany.

Tetany of the newborn may be related to this condition and possibly the maternal parathyroid hyperplasia has depressed the development of the infant's parathyroid glands *Tetany of the newborn*

(f) Citrate tetany

Citrate tetany may very rarely complicate blood transfusion and special are is needed for transfusion after parathyroidectomy.

(g) Phosphate tetany

Tetany may occur in advanced renal failure associated with retention of osphates causing hypocalcaemia

(h) Alkalaemia

Tetany with alkalosis may be due to hyperventilation associated with severe pain, for example renal colic, or as an hysterical manifestation. Tetany may follow the loss of chlorides and retention of bicarbonate with pyloric stenosis, but it is not common with alkalosis due to taking too much alkaline powder, as there is often retention of calcium and magnesium which offsets the effects of alkalaemia on the ionized calcium. *Pyloric stenosis*

(i) Associated with other conditions

Nervous hyper-irritability with convulsions may occur particularly in infants and young children with the onset of any acute infectious disease. In adults the differential diagnosis will include such conditions as meningitis, tetanus, uraemia, poisoning with strychnine, atropine and lead

6. TREATMENT

Emergency treatment

The emergency treatment of tetany consists in the administration of calcium gluconate, 20 millilitres of a 10 per cent solution, which should be injected slowly. Parathormone requires several hours before taking effect and it is of no value for emergency management.

Further treatment depends on the cause. Extra calcium may be administered by mouth as calcium gluconate, for example 4 grammes 4 times daily, or calcium lactate, 2 grammes 4 times daily, given half an hour before meals

Dihydrotachysterol

Sulkowitch test

Vitamin D or calciferol should be given in high doses, 50,000–200,000 units daily. Dihydrotachysterol also promotes calcium retention and phosphorus excretion but its use should be controlled by the Sulkowitch test. This consists of adding oxalic acid and ammonium oxalate in glacial acetic acid to an equal amount of urine. If there is no precipitate, then the serum calcium is below 7·5 milligrams per 100 millilitres. If there is a fine cloud, the serum calcium is probably about normal, but if the precipitate is like milk, the calcium is too high. Dihydrotachysterol is made up in an oily solvent containing 5 milligrams per millilitre and is given by mouth. An initial dose of 3 millilitres daily is recommended until the Sulkowitch test is positive, and then 1–2 millilitres 2 or 3 times weekly may be given.

[References to other titles are given under Tetany in the Index Volume.]

THORACIC AND INTRATHORACIC INJURIES

By W. P. CLELAND, M.R.C.P., F.R.C.S.

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PART I

GENERAL PRINCIPLES

1. DEFINITION AND AETIOLOGY

323.] Chest injuries in times of peace differ considerably from those encountered in war-time. The former consist mainly of stab wounds and crushing injuries, with an occasional gunshot wound; they are inflicted on otherwise

War injuries

normal individuals and usually receive early and efficient attention. War-time injuries, on the other hand, include many penetrating and perforating wounds with ragged shell and bomb fragments in addition to crushing and blast injuries. The wounds are often grossly contaminated and adequate treatment may be unduly delayed. Many patients will have been exposed to the hardships of a war-time existence. Pre-existing lung disease, particularly chronic bronchitis and tuberculosis, may have a significant effect upon the course of an injury to the chest.

Grouping of wounds

In general, chest wounds can be grouped into penetrating and perforating wounds, crush injuries and blast injuries. More important, however, than the type of wound is the injury sustained by the varying structures found within the thorax and the ensuing disturbances of the cardio-respiratory functions.

2. ANATOMY

Apart from the lungs and pleura, the thoracic cavity contains the heart and great vessels, the oesophagus, the trachea and main bronchi, and the thoracic duct, whilst above and below the thorax lie respectively the brachial plexus, and the diaphragm and subphrenic structures. Any of these, either singly or in combination, may be involved in thoracic injuries.

3. PHYSIOLOGICAL CONSIDERATIONS

(1) *Effect on cardio-respiratory function*

Chest wounds differ from wounds elsewhere mainly in their effect upon cardio-respiratory function. These disturbances may occur early and be severe enough to threaten life, demanding immediate rectification as a life-saving measure. On the other hand, eventual function may be impaired by loss of, or damage to, lung tissue, or by pleural thickening and fibrosis, the result of an inadequately treated haemothorax or empyema. Gaseous exchange, venous return and the lesser circulation are most liable to disturbance in the early stages. The diaphragm and intercostal muscles are responsible for maintaining adequate pulmonary ventilation. Actual diaphragmatic injury often results in a temporary paralysis, but many injuries not specifically affecting the diaphragm are associated with a raised and relatively immobile hemidiaphragm. The intercostal muscles and ... muscles of respir... ...d on an intact ...ge for ...heir ...nction. ...grup... ...ge, by

Diaphragmatic injury

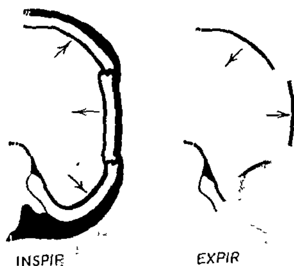


Fig. 74.—, ... due to multiple ri... Diagram ...xical move. unstable

Disruption of thoracic cage

multiple rib fractures, destroys this rigidity, producing an unstable or "flail" area. This region exhibits paradoxical movement on respiration, being sucked in during inspiration and blown out during expiration (Fig. 74). Much respiratory effort is wasted by this flapping of the flail chest wall, and dyspnoea, if present, is always aggravated, sometimes to a degree sufficient to produce severe anoxic changes

The lung is an elastic organ In the normal expanded state the lung completely fills the thoracic cavity and is separated from the chest wall and diaphragm, the movements of which it follows passively, by the potential space of the pleural cavity. In this position the elastic tissue of the lung is stretched; lung expansion is maintained by the capillary attraction and surface tension effects exerted between the two moist pleural surfaces. As air or blood enters the pleural cavity, the lung shrinks by recoil of its elastic tissue and assumes a relatively smaller volume. Complete deflation results in a small airless mass of lung tissue attached by the lung hilum and pulmonary ligament to the mediastinum. In this position ventilation ceases. The accumulation of air or blood in the pleural cavity has the effect, therefore, of gradually decreasing the volume of functional tissue as the lung retracts towards the hilum.

Lung expansion

Complete deflation

(2) Tension pneumothorax

Mediastinal displacement

Should air or blood continue to accumulate after complete lung deflation (tension pneumothorax) the mediastinum will be displaced and the opposite lung and the heart will be embarrassed (Fig. 75). The mediastinal displacement, by distorting and compressing the heart, limits venous return and reduces cardiac output. The combination of decreased ventilation and diminished cardiac output leads to severe anoxia, resulting in death unless relieved.

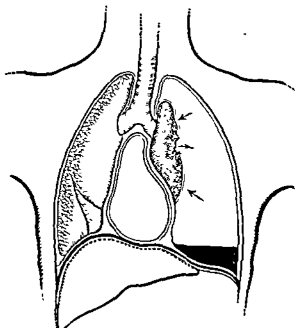


Fig 75 —Tension pneumothorax. Diagram to illustrate the mediastinal displacement and the compression of the opposite lung Note the enlargement of the affected hemithorax.

(3) Open pneumothorax

When a free communication exists between the pleural cavity and the outside air (open pneumothorax; sucking wounds), severe physiological disturbances occur. With each inspiration, air is sucked into the pleural cavity so that the lung, instead of expanding, becomes smaller. Oxygenated inspired air does not enter the lung and the normal gaseous exchange does not occur. The

opposite lung as it expands during inspiration draws some air from the stagnant pool in the affected lung as well as fresh inspired air. The resultant mixture is therefore already partly deficient in oxygen and loaded with carbon dioxide before any exchange occurs. During expiration, part of the expired air from the good lung enters the affected lung, whilst the remainder is expelled naturally. This pendulum movement of air (*Pendel-Luft*) from one lung to the other is the most important effect of the open pneumothorax; it

Pendel-Luft

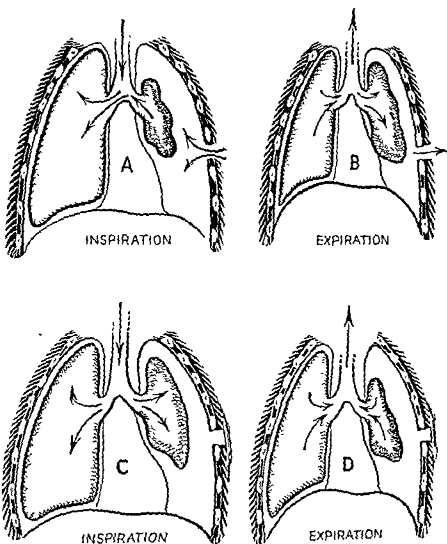


FIG. 76.—Open pneumothorax—sucking wound. Diagrams (*a*) and (*b*) show para- [illegible] movement of air back [illegible] show *reversion* to [illegible] um movements no longer occur.

can be controlled immediately by sealing the chest wall deficiency and thus breaking the cycle (Fig. 76). In addition to the pulmonary changes, *the heart* and mediastinum tend to move from side to side (mediastinal flap or flutter) during this abnormal respiration, and this may have a marked *effect upon* cardiac output.

(4) Effects of pain and bronchial secretions

Pain, by limiting respiratory movements and inhibiting cough, also tends to reduce pulmonary ventilation. Excessive bronchial secretions reduce gaseous exchange by preventing the ready access of inspired air to the pulmonary capillaries (Brewer and his colleagues, 1946).

(5) Cardiac tamponade

The rapid accumulation of blood in the pericardium results in compression of the heart (cardiac tamponade) because the parietal pericardium is relatively tough and unyielding. The thin-walled atria and the great veins are compressed, cardiac filling is decreased, and consequently cardiac output is reduced. All grades of severity are encountered from the acute, rapidly progressive and fatal tamponade to conditions so mild as to be overlooked in the early stages, but presenting with symptoms of constriction at a later date. (*See* Heart and Pericardium, Vol 4, p. 412.)

Reduction in cardiac output

4. RADIOLOGY

Skiagrams play such an important part in the diagnosis and management of thoracic injuries that much care and attention should be paid to obtaining the best possible films. A good



(*a*)



(*b*)

FIG 77.—Horizontal and erect films (*a*) Horizontal A-P. film of crush injury showing dense homogeneous opacity of L. side with no indication as to its nature; (*b*) erect film of same patient showing both fluid and air in the L. chest and an atelectatic lung

Mobile apparatus

portable or mobile machine is essential, as the patients are often unfit for conveyance to the department. Films of good quality can be obtained in the ward if the radiographer is prepared to pay attention to detail, and if it is known beforehand what is likely to be encountered.

Points of practical importance

The following points are of practical importance.

(1) No patient (unless he is moribund) is too ill for radiography, provided that adequate help is available to assist in moving the patient.



(2) *Films should be obtained as soon as possible after the injury.*

(3) *Conditions in the* chest may change rapidly and frequent films are often required, but *this must not lead to* the neglect of an adequate clinical examination.

(a



(b)

FIG 78—Penetrating films. (a) Penetrating P–A film showing rounded empyema shadow behind the cardiac shadow containing a shrapnel ball; (b) left lateral *film showing empyema* and shrapnel ball clearly.

(4) Erect films should always be taken. Horizontal films are valueless in the presence of pleural fluid (Fig. 77).

(5) *Penetrating films will be necessary when there is pleural* fluid or when the presence of foreign bodies is suspected (Fig. 78).

(6) Lateral films should always be taken at the initial examination, *and* subsequently when indicated.

(7) An effervescent powder or gaseous drink is often useful in outlining the left diaphragm in left-sided lesions.

The interpretation of these films can only be made by *those in possession* of the full clinical data, and even then it may be notoriously difficult.

5. MANAGEMENT OF THORACIC INJURIES

(1) First-aid treatment

Many lives can undoubtedly be saved by the timely application of simple first-aid measures: (a) external haemorrhage should be controlled by firm pads and strapping; (b) a sucking wound (open pneumothorax) should be covered by an occlusive pad with Vaseline gauze or Gamgee tissue, and sealed with strapping; (c) a flail or mobile area of the chest wall should be immobilized with firm strapping placed around the affected hemithorax; and (d) a tension pneumothorax should be relieved by inserting a needle into the pleural cavity and removing sufficient air to relieve distress. If the air re-accumulates rapidly, the needle should be fixed in place and connected to an under-water seal.

(2) Transport

A patient with a chest injury, generally speaking, travels better within the first 24–36 hours than later, that is, after relief of shock and before the development of the complications and effects of the injury.

Posture The patient should, as a rule, travel flat, but if there is dyspnoea he will be more comfortable in a semi-erect position.

On arrival at hospital or surgical centre, steps should be taken to correct any physiological disturbances, to arrive at a provisional diagnosis and to decide the treatment to be adopted.

(3) Resuscitation

The first-aid measures already outlined should be taken, if not already applied, or checked and rendered efficient when necessary.

Oxygen Oxygen, given with a B.L.B. mask, will be required by many patients and it is important to see that it is supplied efficiently. Nasal spectacles should be used if the mask cannot be tolerated.

Morphine Morphine in sufficient dosage should be given and repeated when necessary, as it is the only efficient method of relieving pain and allaying anxiety. It should be used with caution when there is cyanosis or bronchial secretion.

Transfusions Transfusions of blood or plasma are always required in the moderate or severe injuries. There seems little danger of overloading the circulation and producing pulmonary oedema if the transfusion is given cautiously. Patients with blast injuries should, however, not be transfused.

Bronchial aspirations Bronchial aspirations, either with a catheter or through a bronchoscope, should be employed in every case in which the natural cough mechanism does not efficiently remove the secretions (Brewer and his colleagues, 1946).

(4) Diagnosis

The determination of the nature and extent of the injuries sustained is often difficult in the early stages, but it is of extreme importance as the whole approach to treatment is based on this early assessment. The following considerations will help to give a comprehensive picture.

(a) An accurate knowledge of the exact type of injury, including an estimation of the track that any missile may have taken within the body.

(b) An assessment of the physiological state of the patient's cardio-respiratory system, for example, cyanosis, dyspnoea, or venous engorgement.

(c) An accurate appraisal of the external wounds including sucking, rib damage, and similar injuries.

(d) Physical signs of significance at this stage are relatively few but of extreme importance, and include the position of the mediastinum, the presence or absence of dullness or hyper-resonance, the presence or absence of breath sounds and signs of bronchial secretions.

(e) Skiagrams should be obtained in all cases as soon as possible after admission. Both antero-posterior and lateral films in the erect position should be taken and also a penetrating film if fluid is suspected. Skiagrams should give information about the following: (1) retained foreign bodies; (2) damage to the bony cage; (3) the state of the lung, whether aerated or atelectatic, expanded or collapsed; and (4) the contents of the pleural cavity.

(f) Exploration of the chest with a needle may give information from a diagnostic point of view.

6. TREATMENT OF THORACIC INJURIES

The question of conservative treatment *versus* operative treatment in the early stages is one which may be easily decided in many cases, whilst in others the decision can only be arrived at with difficulty, and much will depend on the experience of the clinician and the facilities he has at his disposal. Surgical treatment inside the pleura should not be attempted unless the surgeon is prepared to cope with any or all of the possible conditions which he may encounter. Major thoracotomies are therefore better undertaken in recognized thoracic centres or by mobile surgical teams in which an experienced anaesthetist, a trained surgeon and adequate equipment are all available. Should such facilities not be available, it is wiser to pursue a conservative policy.

(1) General principles

Only a general guide as to the line of treatment can be given here.

(a) Injuries which should be treated conservatively include the following: (i) crush injuries, (ii) blast injuries; (iii) small non-sucking penetrating or perforating wounds associated with a haemothorax; (iv) cardiac wounds not associated with tamponade or massive haemorrhage; and (v) simple thoraco-abdominal wounds not exhibiting signs of grave intraperitoneal damage.

(b) Among the injuries which require major surgical treatment within the first 48 hours after a period of adequate resuscitation may be listed: (i) sucking wounds; (ii) extensive wounds with fragmentation of ribs; (iii) large retained foreign bodies; (iv) complicated thoraco-abdominal wounds; (v) persistent haemorrhage either internally into the pleural cavity or pericardium, or externally through the wound or the bronchial tree; and (vi) cases in which organic foreign bodies are suspected.

(c) Cases requiring later operation include those with (i) clotted haemothorax—treated by thoracotomy, evacuation of clot and decortication of the lung; (ii) infected haemothorax not responding to adequate aspirations and chemotherapy. These cases require drainage if the empyema is small, or

decortication if it is large; (iii) diaphragmatic hernia; (iv) foreign bodies causing persistent symptoms; and (v) septic complications in the lung or pleura. These are treated according to general surgical principles.

(d) A remote operation is indicated for (i) closure of a chronic empyema; (ii) removal of foreign bodies, and (iii) resection of bronchiectatic lung if producing symptoms.

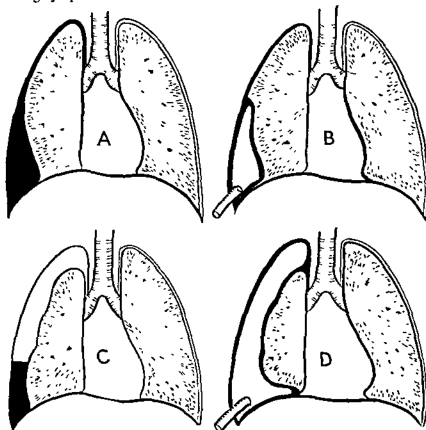


FIG. 79—Haemothorax Diagram to illustrate the effects of aspiration with and without air replacement (*a*) Fluid collected at base Pleural layers at apex are in contact and becoming adherent; (*b*) shows empyema pocket limited by pleural adhesions which developed in (*a*); (*c*) shows the position after air replacement The air rises to the apex and prevents fusion of the lung to the chest wall; (*d*) represents the extensive empyema which would develop in (*c*) should it become infected

(2) Conservative treatment

Many of the war-time wounds were treated conservatively but actively with excellent results. Major surgical treatment was employed either to save life or to avoid the effects of prolonged pulmonary or pleural sepsis or the production of a "frozen" chest. If facilities are not available for major surgery and its [illegible] is better treated along active [illegible]

(*a*) *Aspiration of the haemothorax*

Aspiration of a haemothorax may be required within a few hours of injury should there be signs of a large accumulation of blood in the chest, with

Discomfort

mediastinal displacement and dyspnoea. Discomfort is often considerable, and much relief and often dramatic improvement follow aspiration.

Early aspiration

Apart from the above indications for emergency aspiration, all cases should be aspirated within the first 48 hours of the receipt of the injury. In this the irritant blood is removed early and lung expansion encouraged. There never been any convincing evidence that early aspiration leads to a recurren of bleeding. Aspirations should be repeated at intervals of 2–3 days until flui is no longer obtained and the skiagrams show satisfactory resolution.

Penicillin

Penicillin in doses of 200,000–300,000 units is injected intrapleurally after each aspiration. It is the practice of most surgeons in Great Britain not to replace the aspirated blood with air. Air introduced in this way will rise to the top of the thoracic cage, where it will separate the apex of the lung from the chest wall and prevent the two from adhering. Should an empyema develop later, a much larger area will be affected (Fig. 79).

Site for aspiration

The site for aspiration will usually be posterior, but in the early stages and with large collections an axillary site can be used; in this position the patie can lie supported on pillows with the arm held out of the way, and th operation will be less exhausting

Aspirations can conveniently be carried out with a 20-millilitre syringe, an air-tight 3-way adapter and a 3–4-inch 17 B.W G. needle. At each aspiration as much fluid as possible should be removed without distressing the patient.

Causes of "dry tap".—The causes of a "dry tap" are given below.

(1) Wrong site for aspiration. Before each aspiration, the site should be checked by radiological and clinical signs. If fluid levels are present these should be accurately localized and the needle inserted at that level.

(2) Too small a needle.

(3) Puncture placed too low. In many chest injuries the diaphragm is siderably raised but will be obscured by the haemothorax.

(4) Massive clotting.

(5) Presence of villous tags of fibrin which persistently block the needle.

(b) *Physiotherapy*

Breathing exercises are started within the first few days after injury and combined with postural and arm exercises. Individual exercises are continued whilst the patient is in bed, but graduation to sitting and standing classes is encouraged. The importance of adequate physiotherapy in maintaining good posture and in preventing contraction and deficient mobility of the affected hemithorax cannot be over-emphasized

(c) *Control of bronchial secretions*

In the early stages when pain and a damaged chest wall reduce the efficacy of coughing, every endeavour should be made to make the patient remove his secretions. Frequent encouragement, both physical and verbal, by nursing and medical staff, will aid considerably, while the judicious use of morphine will also help. Laying the patient flat in bed, first on one side and then on the other, is also of assistance. Whenever these measures fail, bronchoscopic or catheter aspiration of the secretions will be required (Brewer and his colleagues, 1946).

Bronchoscopy can very easily be carried out in the ward with the patient lying supported semi-upright on pillows. The surgeon operates over the head-end of the bed, and it is surprising how easy is the passage of the bronchoscope. Local anaesthesia should be used sparingly as it is wise to retain the cough reflex. Intravenous morphine is of considerable help. Relief is often dramatic and most gratifying. *Bronchoscopy*

(d) General measures

These measures should include ambulation as early as possible, for this undoubtedly helps to improve chest movements and lung re-expansion as well as encouraging the dislodging and removal of bronchial secretions, and it often has a profound psychological benefit.

(3) Early operative treatment

The indications for early thoracotomy have already been outlined and emphasis has been laid upon the desirability of having available as fully trained a team as possible. Surgery should only be attempted after a period of resuscitation including transfusion, oxygen therapy, first-aid treatment and bronchial clearing. It should be realized, however, that cardio-respiratory function may remain poor until corrected by the surgical procedure, so that maximal improvement may not be obtained during the period of resuscitation. *Poor cardio-respiratory function* Transfusions should be continued during and after the operation, and several pints of blood should always be available. *Transfusions*

(a) Anaesthesia

Endotracheal intubation with a cuffed tube to permit positive pressures and control of respiration is essential. Cyclopropane was used extensively during World War II, but recently anaesthetists have preferred to use Pentothal Sodium, curare, gas and oxygen with or without positive pressure and control of the respiration according to the needs.

(b) Attention to wounds

These should receive adequate toilet, with excision of edges and removal of all foreign bodies and loose rib fragments.

(c) Thoracotomy

In many cases one of the wounds can be suitably enlarged to permit an adequate inspection of the thoracic contents, but when this is not practicable a separate deliberate thoracotomy is planned according to the expected site of the injuries. An intercostal incision is usually sufficient, but more room can be obtained by excising an inch-segment of the upper rib well posteriorly and dividing the intercostal bundle. *Intercostal incision* The incision is opened widely with rib spreaders. The pleural cavity is cleared of clot and blood, and care is taken to remove any foreign bodies or rib fragments lying free in the pleural cavity or projecting into it. The lung is then examined and palpated or explored gently for evidence of foreign bodies which, if located, should be removed. *Examination of lung*

Small or moderate lacerations should be loosely sutured with catgut, fine thread, or silk. Severely damaged areas are better treated by lobectomy or *Lobectomy*

wedge resection. The lung possesses considerable recuperative powers, however, and one should therefore err on the side of conserving tissue whenever possible.

Examination of diaphragm

The diaphragm should be examined in suspected thoraco-abdominal injuries. If lacerated, the tear can be enlarged sufficiently to permit a thorough exploration of the adjacent abdominal viscera which, if damaged, can then be dealt with. The diaphragm should be repaired with non-absorb mattress sutures producing a half-inch overlap of the edges. The phre nerve should be crushed if the diaphragm has been extensively involved.

Closure of chest wall

Drainage of pleural cavity

The chest wall is closed in layers after powdering or spraying the pleur cavity with penicillin or penicillin-sulphathiazole mixtures. The pleural cavit should be drained in the majority of cases, using either a basal tube or basa and apical tubes. The basal tube allows all blood and exudate to escape as it forms, whilst the apical tube allows air to escape and encourages the full and early expansion of the lung which is so desirable. Both tubes are connected to an under-water seal for the first 12–24 hours, but suction drainage can be employed later if lung re-expansion appears to be delayed. Usually both tubes are removed between the second and the fourth day, following which pleural collections should be aspirated.

Physiotherapy and early ambulatory treatment are of vital importance after operation, as already indicated.

(4) Later operative procedures

The later procedures are mainly concerned with the treatment of sepsis and will include drainage of the pleural or subphrenic spaces, the treatment of lung sepsis by drainage or resection and the treatment of the clotted or infected haemothorax by decortication.

(5) Remote operations

These are concerned chiefly with the removal of foreign bodies, the final closure of a chronic empyema and the resection of bronchiectatic lung tissue if producing symptoms such as haemoptysis.

PART II

MANAGEMENT OF SPECIFIC CHEST INJURIES

1. INJURIES TO THE PARIETES

(1) Ribs

Direct fractures can occur at any site; splintering is common and the fragments may project into the pleural cavity and damage the lung, or they may be carried far into the lung by the missile. Intercostal vessels may be injured at the same time and these may be responsible for severe or persistent bleeding. *Direct fractures*

Indirect fractures are usually multiple and tend to occur at the site of greatest *Indirect fractures*

Multiple rib fractures

stress and least strength (burst fractures). Lateral compression produces fractures at the anterior and posterior angles whereas antero-posterior compression results in lateral fractures. Extreme examples of multiple rib fractures result in two serious phenomena which are: (a) the stove-in chest, and (b) the flail chest wall; either may seriously embarrass respiration as much from a disturbance of the mechanics of the chest wall as from associated pain.

Treatment

Pain and paradoxical movement are the two effects of rib fractures requiring attention. Both can usually be relieved by firmly strapping the affected area with adhesive plaster. In addition, pain can be relieved by blocking the affected intercostal nerves with procaine, or an oily preparation such as Proctocaine which has a more prolonged action.

Severe disruptions

Patients with severe chest wall disruptions not amenable to immobilization with strapping should be placed in a Drinker or similar mechanical respirator.

(2) Costal cartilages

Costal cartilages exposed in a wound should be completely removed owing to the dangers of necrosis with persistent discharging sinuses. Adjacent cartilages are liable to be involved and not infrequently the whole costal margin has eventually been affected. Radical excision is required should this occur.

(3) Sternum

Open wounds

The sternum is occasionally fractured by indirect violence in association with fractures of the thoracic spine. Open wounds involving the sternum should receive particularly careful attention owing to the liability of the sternum to chronic infection with persistently discharging sinuses.

(4) Foreign bodies

Foreign material should be removed whenever possible at the time of any early operation. This applies particularly to organic material (including rib fragments). Residual foreign bodies in the parietes should be dealt with according to general surgical principles.

2. INJURIES TO THE PLEURA

The potential space of the pleura lies between the chest wall on the one hand and the intrathoracic structures on the other, and is usually implicated in injuries to either. Normally occupied by an elastic and expanded lung, the space can accommodate considerable quantities of foreign material, by displacing the lung which contracts by elastic recoil and becomes less well aerated and expanded.

Abnormal materials within pleural cavity

The following abnormal materials may be encountered within the pleural cavity. (a) Air from a breach in the parietes or a tear in the lung, bronchi or trachea, or produced by gas-forming organisms. (b) Blood from vessels in the chest wall, lung, mediastinum or below the diaphragm. (c) Chyle.

(d) Bile. (e) Pus. (f) Ingested material from the oesophagus, stomach or intestines. (g) Metallic or organic foreign bodies.

Various combinations of the above may be found in any particular individual.

(1) Pneumothorax

Air, alone, is an uncommon finding after chest trauma; it is usually associated with blood as well—haemopneumothorax. Three clinical varieties are encountered.

(a) *Simple pneumothorax*

This occurs when there is a limited non-recurrent entrance of air into the pleural cavity and it may follow any type of chest wound, including crush and blast injuries. It is more prone to occur in the elderly patient with emphysematous lungs, probably due to rupture of a subpleural bulla or tearing of friable lung. Absorption of the pneumothorax and re-expansion of the lung occur rapidly and, as a rule, special treatment is not required. *Age incidence*

(b) *Tension pneumothorax*

In these cases there is a constant or recurrent leak of air into the pleura either from the lung or from a valvular wound in the parietes. Air is sucked into the pleura on inspiration, but during expiration its escape is hampered so that it accumulates. The air first compresses and collapses the lung and later displaces the heart and mediastinum towards the opposite side, producing serious embarrassment to both the cardiac and respiratory mechanisms. The pressure of the air trapped in the pleura may reach 30 or more centimetres of water.

Respiratory distress may be acute and pain in the chest considerable. Immediate relief in desperate cases can be obtained by plunging a needle into the affected cavity through the second intercostal space in front and allowing air to escape. Subsequently, air should be removed by aspiration using pneumothorax apparatus; serial readings of the pleural pressures as air is removed will indicate the presence or not of a fistulous leak. An indwelling needle or small catheter connected to an under-water seal will be required if the accumulation of air continues and cannot be controlled by repeated removal of air by aspiration. *Relief of respiratory distress*

(c) *Open pneumothorax (sucking wound)*

In these cases there is a free communication between the pleural cavity and the outside air. The lung is deflated and collapsed and such air as it contains oscillates back and forth between the sound lung and the affected lung (pendulum movement). In addition, the mediastinum moves from side to side with respiration (mediastinal flap). The resulting physiological disturbances are considerable and have already been described. The external wound may be obvious both to eye and ear or it may be temporarily sealed or concealed by matted clothing and clot or even by the patient lying on and occluding the opening. *Physiological disturbances*

Dramatic improvement follows the "first-aid" sealing of the wound with an occlusive pad kept in position by adhesive plaster. This should be followed

Surgical repair

by the aspiration of as much air as possible from the pleural cavity. Surgic repair of the chest wall deficiency is necessary in all cases.

(2) Haemothorax

Causes

A haemothorax is by far the commonest complication of a thoracic woun and is found in about 70 per cent of cases; this is because the pleural cavit has common boundaries with both the thoracic cage and the intrathoraci viscera and may be involved in injuries to either. The pleural space is capabl of accommodating considerable quantities of air or blood and offers littl resistance to its accumulation (compare a haematoma in body tissues). Bloo may come from damaged vessels in the chest wall (intercostal and intern mammary vessels) or from the lung, heart, diaphragm or subphrenic organs Damage to a large vessel may be rapidly fatal whilst injury to smaller vessel may produce haemothoraces varying from a few ounces to several pints

Cessation of bleeding

Bleeding almost always ceases within 12–24 hours of wounding and there is n convincing evidence that early aspiration (that is, aspiration on the first o second day after wounding) of the haemothorax causes a recurrence of th bleeding.

(a) *Types of haemothoraces*

Haemothoraces can for convenience be divided into two main type (Hoyle, 1940).

(i) *Simple haemothorax*.—This is a type in which the pleural blood constitutes the main result of the injury and is the chief feature requiring treatment.

(ii) *Complicated haemothorax*.—This condition, on the other hand, is one in which the haemothorax is a mere incident associated with more serious injuries to other viscera; in this group, treatment of the haemothorax assumes secondary importance.

Haemothoraces following sucking wounds and thoraco-abdominal wounds or associated with severe lung trauma or large foreign bodies, constitute examples of this latter group.

(b) *Pathology*

Blood in the pleural cavity acts as an irritant with the formation of a protein-rich effusion This exudate causes a progressive increase in the size of the haemothorax and may be mistaken for continued bleeding—an assumption which is not borne out if the haemoglobin and red-cell content of successive samples of aspirated fluid is estimated. Both the original blood and the

Fibrin masses

irritant effusion are fluids rich in protein, fibrin masses form readily and are deposited on both the visceral and parietal surfaces of the pleura where they become organized to form fibrous tissue. Thus within 3 weeks of the injury an untreated haemothorax is surrounded by a capsule of well-formed fibrous tissue covering both surfaces of the pleura. The visceral layer covering the lung binds it down and prevents its re-expansion; the parietal layer lining the chest wall and diaphragm causes approximation and crowding of the ribs and contraction and immobility of the chest wall and diaphragm. Slowly the pleural collection is invaded by the organizing wall until finally it is replaced by a mass of fibrous tissue. Large collections may be quite impossible to

obliterate completely in this way and a residual cavity may remain for many years. Such a cavity is always liable to become infected (*see* Fig. 79) and calcification is not an uncommon finding. It may present clinically years after the original injury as a chronic calcified empyema. The final picture of a neglected haemothorax shows a "frozen" chest with marked scoliosis, considerable contraction and immobility of the hemithorax and a lung encased in rigid fibrous tissue. Function in the imprisoned lung is very seriously impaired.

Residual cavity

Chronic calcified empyema

(*c*) *Clinical features*

There are few distinctive symptoms and fewer diagnostic signs of a haemothorax and in all cases the diagnosis can only be made with certainty by the aspirating needle.

Chest discomfort

Chest discomfort and actual pain are frequent and are due to the irritant nature of the blood or to tension in the pleural cavity; both are often relieved immediately by aspiration. Fever is a constant finding and most uncomplicated haemothoraces have a low-grade fever rising to 100° F. and settling slowly in 7–10 days.

Fever

The signs may be unequivocally those of an effusion, but associated pathological changes often obscure the findings and confuse the clinician. The most relevant of these pathological changes are mentioned below.

Pathological changes

(1) Pulmonary atelectasis beneath the haemothorax accounting for the presence of bronchial breath sounds and the absence of mediastinal displacement even with a very large haemothorax.

(2) A high diaphragm which may mimic a large haemothorax.

(3) Pockets of air incorporated in the haemothorax, which may produce most bizarre signs.

Radiological signs

The radiographic appearances, like the physical signs, may be quite obviously those of an effusion or may be complicated by associated lesions. Small collections show little beyond a slight "ground glass" appearance at the base on the antero-posterior film, but the lateral picture will often show a much better defined triangular shadow filling up the posterior costo-phrenic sinus. Even in such cases with minimal radiological signs it is often surprising how much blood can be aspirated. Should air be present in addition to blood a fluid level will appear, in such cases loculation is frequent. Particular attention should be paid in all cases to the state of the underlying lung.

(*d*) *Treatment*

All haemothoraces, however small, should be aspirated; blood is a pleural irritant and even small quantities will produce an effusion and result in some thickening of the pleura. The radiological and clinical signs are often very misleading regarding the size of a haemothorax, apparently minimal collections producing a pint or more of blood on aspiration. It is therefore wise to aspirate all cases and aspirate them early in order to prevent the secondary effects which inevitably follow an untreated haemothorax.

Aspirations

Aspirations should be started within the first 24–48 hours after the injury and repeated at intervals of 2–4 days until fluid is no longer obtained from any site and the skiagram appears clear. Air replacement is not advised even in the early stages because air rises to the top of the pleural cavity; in this position it is difficult to remove at a later date and it will prevent expansion

of the apex of the lung. (For details of aspiration see Treatment of Thorac Injuries, p. 212.)

Aspirations are combined with intense physiotherapy, with breathing an postural exercises, and ambulation is encouraged as soon as possible.

(e) *Complications*

Infection and massive clotting are the most frequent complications c a haemothorax.

(3) Infected haemothorax

Varieties of organisms

Infection occurs in 30 per cent of all cases but its probability depends largel on the type of wound. Clean stab wounds and bullet wounds rarely lead t infection whereas injury by bomb or shell fragments is associated with a high incidence of infection. Many varieties of organisms may be found either as primary or secondary invaders. The commonest are streptococci and staphylococci, organisms of the coliform group, *Bacillus proteus* and *B. pyocyaneus*. Gas-forming organisms and other anaerobes are not infrequently encountered in war wounds.

(a) *Pathology*

Pus formation

Penicillin therapy

Gross pus formation in an infected haemothorax may be considerably delayed by the surrounding barrier of thickened fibrous tissue or it may be masked by the presence of considerable quantities of blood. First suspicions are often aroused after routine bacteriological examination of aspirated fluid. The haemothorax fluid at this stage may appear quite innocuous but often it exhibits a somewhat purplish colour and a distinct stale, musty or even offensive odour. Pus formation occurs gradually and its development can be observed if successive samples of aspirated fluid are retained and compared. Efficient aspiration and penicillin therapy will modify the course of the pathological process but in the majority of cases the phenomena of a typical empyema eventually become obvious.

(b) *Clinical features*

Toxaemia

Diagnosis

Essential exploration

The most constant and reliable sign of infection is a rise in temperature over and above the fever of 99°–100° F. which is so frequently found during the first week of a simple uninfected haemothorax. Toxaemia often appears rapidly and considerable wasting can occur in a few days. Diagnosis rests finally with the exploring needle though the finding of uninfected fluid at one site does not exclude infection, as haemothoraces are frequently multilocular, with the cytology and bacteriology often varying in the different pockets. It is, therefore, essential that exploration should be carried out at several sites when infection is suspected on clinical grounds but not confirmed by the first aspiration.

(c) *Treatment*

The details of the management of an infected haemothorax vary although the principles remain essentially the same. The principles are:

(i) *Control of infection.*—Infection may be controlled by (a) repeated aspiration and intrapleural chemotherapy, and (b) closed drainage with an



(*a*)



(*b*)



(*c*)

FIG. 80.—P-A. films of neglected clotted haemothorax treated by evacuation of clot (*a*) Three months after injury, with a haemothorax which could not be aspirated, (*b*) after thoracotomy with evacuation of clot (but no decortication) showing imperfectly expanded lung and a collection of fluid in the pleura; (*c*) three years later, showing the gross deformity of a "frozen" chest.

intercostal Malecot catheter if the above does not control infection and toxaemia.

(ii) *Elimination of dead space.*—Dead space may be effectively eliminated by (a) drainage after rib resection posteriorly and towards the lower limit of the space employing closed drainage in the first instance and open drainage later, and (b) thoracotomy with evacuation of clot and debris and decortication of the lung and chest wall as described below under clotted haemothorax (Fig. 80). This procedure has been employed with success in large empyemas (Fig 81) but it is a major procedure requiring skilled operative and post-operative care and is best carried out in a chest centre. (Thomas and Cleland, 1945; Burford, Parker and Samson, 1945.)

The subsequent management is similar to that of an empyema. Drainage must be maintained until skiagrams, with iodized oil outlining the empyema, no longer show a residual cavity.

Intensive physiotherapy and early ambulation are of fundamental importance.

(4) Clotted haemothorax

Massive clotting of blood in a haemothorax occurs in 10 per cent of all cases. Many explanations have been given for the occurrence of clotting, or, perhaps, more pertinently, the lack of clotting, in a haemothorax The most probable explanation would appear to be that in the majority of cases the blood is defibrinated by the churning movements of the heart and lungs (Sellors, 1945). These movements are likely to be excessive due to the tachycardia and dyspnoea associated with chest trauma. The fibrin so produced is small in bulk and is deposited on the pleural walls or sinks to the base of the haemothorax. Massive clotting may, therefore, occur either early, when defibrination has not taken place, or later, from clotting of the blood mixed with the protein-rich exudate occurring as a result of the irritation of the pleura.

Defibrination of blood

Massive clotting

(a) *Pathology*

The pleural changes already described under haemothorax occur to a more pronounced degree. A rapidly organizing "rind" is found surrounding the pleural haematoma and the latter is slowly invaded by fibroblasts and replaced eventually by fibrous tissue. Natural absorption of clot does not occur to any significant degree. The final picture of an untreated clotted haemothorax of moderate size is one of severe deformity, with scoliosis, contraction and immobility of the chest wall and fixation of the underlying lung. Function of the latter is markedly impaired. The condition has aptly been called the "frozen chest".

Frozen chest

(b) *Clinical features*

The general features of a clotted haemothorax differ little from those of the fluid type. The diagnosis is made only on the inability to aspirate the haemothorax, after other causes of a dry tap have been excluded (*see* Treatment of Thoracic Injuries, p. 212). Small quantities of blood and shreds of clot are often obtained with some difficulty but effective aspiration is never possible when clotting has occurred.

Diagnosis

The radiological appearances differ according to whether or not air is associated with the blood. The pure haematoma (Fig 82) shows as a dense homogeneous well-circumscribed shadow whilst a clotted haemopneumothorax shows multiple air pockets with fluid levels and intervening strands of clot of varying thicknesses. The appearances are not unlike those of the bowel and the condition can be confused with a diaphragmatic hernia. Infection with gas-forming organisms is not infrequent and may produce a typical x-ray appearance. The solid clot is broken up by a series of small gas-bubbles and appears like a sponge (Fig. 83); the loculated type may show considerable distension of the loculi which appear tense and spherical and may cause enlargement of the affected hemithorax (Fig. 84)

Radiological signs

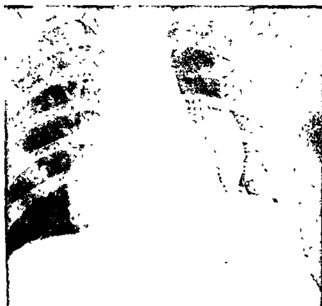
Confusion with diaphragmatic hernia

(*c*) *Treatment*

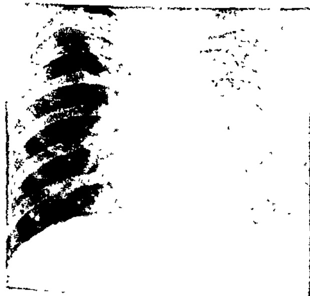
Small collections of clot can be dealt with by a combination of aspiration, absorption and organization without grave diminution of function if care is taken, by vigorous and prolonged physiotherapy, to maintain adequate mobility of the chest wall and diaphragm.

Larger masses of clot, and particularly infected cases, should be treated by open thoracotomy with

Open thoracotomy



(*a*)



(*b*)

Fig 81.—A-P films of total drained empyema (infected haemothorax) treated by decortication (*a*) Condition on 25 9 44 showing total empyema with an unexpansible lung covered by a layer of fibrous tissue, (*b*) condition on 30 11.44, two months after decortication and suction drainage with lung fully expanded and wounds healed

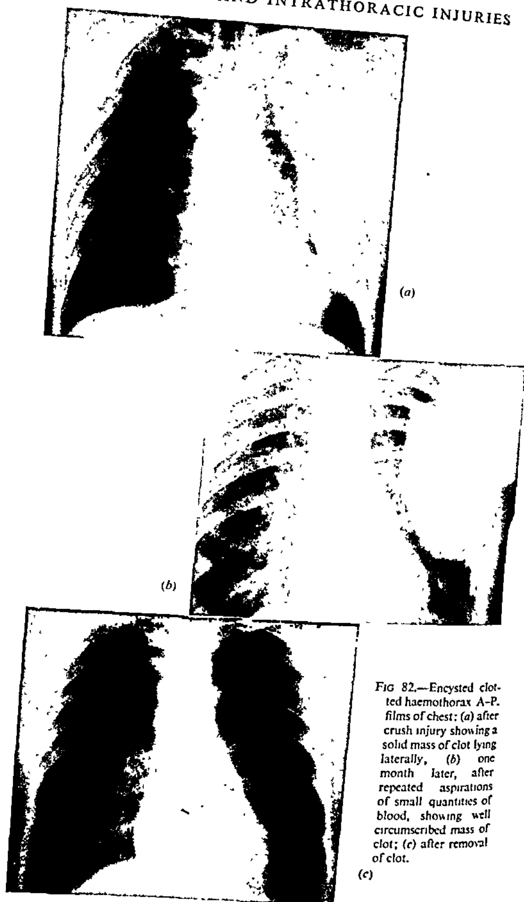


FIG 82.—Encysted clotted haemothorax A-P. films of chest: (a) after crush injury showing a solid mass of clot lying laterally, (b) one month later, after repeated aspirations of small quantities of blood, showing well circumscribed mass of clot; (c) after removal of clot.

evacuation of clot and decortication of both lung and chest wall (Figs. 81 and 82). (Lush and his colleagues, 1944; Thomas and Cleland, 1945)

A standard postero-lateral intercostal thoracotomy gives adequate access in the majority of operations, but in cases with established contraction of the chest wall, division or resection of a rib above and below may be necessary to improve the exposure.

The parietal layer of the haematoma is incised and the central mass of clot and debris is then removed. The visceral layer of organizing fibrin covering the lung is then carefully incised until the easily recognizable grey shining layer of visceral pleura is reached. Then by a process of gentle blunt dissection with a small swab in a holder, or using a long curved haemostat as a blunt dissector, the layer is gradually peeled away from the underlying lung. It is essential in all but the very localized haematomas to decorticate the lung completely so as to undo any puckerings or infoldings of the lung and free it from any abnormal attachments. It is not uncommon to find the lung folded and buckled on itself, with the apex adherent to some point

Gentle dissection

Decortication of lungs



FIG. 83.—Infected clotted haemothorax. P–A film showing spongy mass of infected clot in the base of the pleural cavity.



FIG. 84.—Infected clotted haemopneumothorax. P–A. film showing typical appearance of multiple air spaces.

in the lower ... is completely ... moved it wi... muscles as the fibrous tissue contracts; deformity and immobility will ensue and subsequent function will be impaired. The procedure is a major one and requires time and patience. Blood transfusion is necessary during the operation.

Blood transfusion

Following decortication, the aim is to ensure rapid and complete expansion of the decorticated lung so as to eliminate the dead space as soon as possible. If full expansion is delayed, fibrin rapidly reappears in the pleura and may jeopardize the result. To achieve this early and complete expansion, suction drainage is employed using both an apical tube (through the second space between scapula and spine) and a basal tube. The apical tube permits the continuous removal of air which may leak temporarily from small alveolar lacerations. Suction is continued for 2–3 days after full expansion has occurred and after a trial period of 12 hours with both tubes clamped; it is followed by x-ray examination to ensure that expansion is maintained. Both tubes should then be removed, taking care to prevent air being sucked into the pleura before the drainage site is sealed. Aspirations are rarely required subsequently, owing to the early fusion of the decorticated lung surface to the parietes.

Suction drainage

3 INJURIES TO THE LUNG

The lung occupies a large proportion of the thoracic cavity and is frequently involved in any form of trauma to the chest. It may be involved directly (contusion or laceration) or indirectly (atelectasis, pneumonic consolidation, abscess, gangrene, and the like).

(1) Contusion

Lung contusion without penetration of the chest wall may follow the impact of blast waves following explosions (blast injury) or of solid material, such as masonry (crushing injuries). Blast injuries may occur when the subject is in fairly close proximity to an exploding bomb, mine or shell. The waves are readily transmitted through water as well as air so that typical lesions may be found with under-water explosions. The blast waves are readily deflected by solid objects such as a wall or a building. In the lungs scattered small contusions or haematomas occur and in severe cases these become confluent, forming massive intrapulmonary haemorrhages. Severe cases survive no longer than a few minutes or hours and die from anoxia Less severely affected patients are cyanosed and anoxic with tachycardia and rapid respiration and haemoptyses are frequent. Patients exhibit a shock-like state out of all proportion to the apparent injuries. Gaseous exchange may be further hampered by the presence of blood-stained secretions in the bronchial tree. Skiagrams show coarse mottling in the lung fields which may be confluent in places (Fig. 85) Symptoms begin to subside after 2–3 days; the x-ray appearances may take 3-4 weeks to disappear but resolution is always complete. Treatment consists of adequate oxygen administration and rest. Transfusions must be given with considerable caution (Savage, 1945; Fearnley, 1945).

Blast injuries

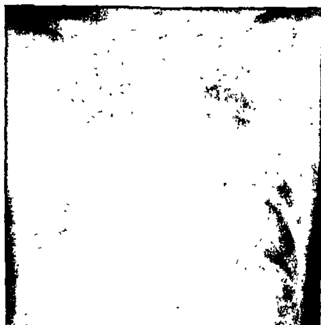
Effect in lungs

eatment

Localized contusions or lung haematomas may occur after crush injuries *Crush injuries* and are an almost invariable accompaniment of a penetrating wound. The condition is one of academic and radiological interest, and does not require any special specific treatment. Haematomas not associated with retained foreign bodies rarely become infected; they are partly absorbed and partly removed *via* the bronchial tree.

(2) Lacerations

The lacerated lung possesses remarkable reparative powers unless the larger bronchi or blood-vessels are damaged. Gross infection of lacerated *Gross infection* lung is rare except when associated with retained foreign bodies. The immediate dangers of the more superficial lacerations are haemorrhage or the leakage of air. Bleeding from the low-pressure lesser circulation is rarely excessive (except when a large vessel is involved) and is probably soon controlled by the concomitant lung collapse and compression. Extensive lacerations, however, may effect the virtual separation of a portion of lung; such cases will usually present indications for early thoracotomy. *Indications for early thoracotomy*



(a)



(b)

FIG. 85.—Blast injuries. (a) P-A. film 10.9.40 taken 24 hours after exposure to the blast of a near-by bomb showing considerable perihilar opacities and mottling in the lungs. (b) P-A. film 12.9.40 showing considerable clearing of the opacities.

(3) Atelectasis

Lobar or total atelectasis on the injured or the opposite side is frequently encountered in chest wounds, being particularly common in adult males with crush injuries. The majority of these cases are due to bronchial occlusion by abnormal secretions, though other causes are compression by large collections of blood or air in the pleura, the very occasional severance of a bronchus and the operation of certain neurogenic factors.

Precipitating factors

Precipitating factors are: (1) pre-existing chronic bronchitis; (2) the presence of painful chest injury or flail chest wall which reduces the efficacy of coughing; and (3) the presence of blood, mucus or pus in the bronchial tree, which is especially dangerous if there is dehydration with inspissation of the secretions.

Treatment

Treatment in the first place is designed to correct any of the above precipitating factors and is combined with postural drainage, percussion therapy and the encouragement of coughing. Bronchoscopic or catheter aspiration should be employed when the lung does not expand after 24 hours in order to avoid the extension of infection in the collapsed lobe.

(4) Foreign bodies in the lung

The significance of foreign bodies in the lung depends on their size and structure, shape and position. Their danger lies in their liability to determine infection in the surrounding lung, resulting in suppuration or abscess formation. Later they may be responsible for haemoptyses as well as ill-defined complaints of a psychological nature.

(*a*) *Size*

A metallic foreign body less than a centimetre across its largest diameter is unlikely to give rise to either immediate or remote symptoms sufficient to justify early removal.

(*b*) *Structure*

Organic foreign bodies such as rib fragments and portions of clothing are very prone to determine infection in the surrounding lung and should be removed whenever possible.

(*c*) *Shape*

Metallic foreign bodies with irregular jagged edges seem more prone to cause trouble than smooth rounded objects such as a rifle bullet. This is because an irregular fragment causes more tissue damage and is more likely to carry with it fragments of clothing or ribs.

(*d*) *Position*

Foreign bodies half-embedded in the lung and projecting through the pleura into the pleural cavity are serious in that they tend to perpetuate a fistulous leak from lung to pleura and are liable to produce an empyema (Fig. 86). Foreign bodies near the hilum may ulcerate into one of the larger pulmonary vessels or bronchi.

Late effect

The most frequent late effect of a retained foreign body is haemoptysis. Such cases should be investigated with bronchography; if bronchiectasis is

present, segmental or lobar resection is advisable but if not, local removal or wedge resection can be employed.

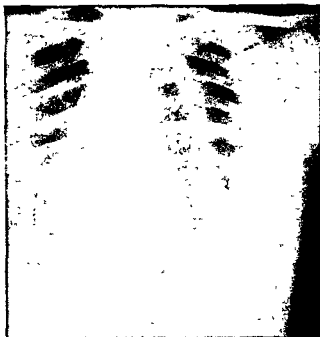


FIG. 86—P-A. film showing a persistent empyema with a broncho-pleural fistula due to a foreign body half-embedded in the lung. Rapid resolution followed the removal of the foreign body.

4. INJURIES TO THE HEART AND PERICARDIUM

Cardiac and pericardial wounds and injuries are not common. Patients with severe injuries do not survive to reach medical aid and many minor injuries escape detection altogether. In peace-time, stab wounds account for the majority of cases, whilst in war, penetration by metallic fragments is more frequent. Haemorrhage and disturbances of the neuro-muscular mechanism of the heart or actual infarction from damage to a coronary vessel are the early manifestations of a cardiac injury. Haemorrhage is by far the most frequent and important; it may come from a pericardial vessel, from the cardiac muscle or coronary circulation or from the heart chambers or great vessels. In amount it may vary considerably from a massive haemorrhage leading to rapid death to a mere trickle of an ounce or two of blood. *Early manifestations*

(1) Clinical types

Clinically, three types of injury may be encountered.

(1) Massive or persistent external haemorrhage from a penetrating wound in the vicinity of the praecordium. *Haemorrhage*

(2) Massive haemothorax, often out of all proportion to the severity of the injury. In this group there is a traumatic communication between the pericardium and the pleura; blood does not accumulate in the pericardial sac and tamponade does not occur. The clinical features are those of a severe internal haemorrhage with a large haemothorax. Churning sounds over the praecordium may be heard *Haemothorax*

Tamponade

(3) Cardiac tamponade is due to the accumulation of blood *within the* relatively rigid and unyielding pericardial sac. As a result the heart is compressed, diastolic filling greatly interfered with and cardiac output markedly reduced. Compression is most readily exerted upon the thin-walled atria and the great veins. Clinical disturbances may be profound with the patient unconscious and *in extremis* in severe cases. The severity of the condition appears out of all proportion to the injuries received. The pulse is weak or imperceptible and the blood and pulse pressures are both greatly reduced The characteristic finding is enlargement of the jugular veins. The heart sounds may be very faint but are sometimes well heard as the heart may be pushed forwards by blood collecting posteriorly. Diagnosis should be confirmed and temporary relief obtained by exploring the pericardium with a needle inserted through the left xiphi-costal angle in an upward and backward direction slightly inclined to the left. Surgical exploration is a matter of urgency.

Clinical disturbances

Diagnosis

Treatment

Blood transfusion

In all cases of recent cardiac wounds with signs of haemorrhage or tamponade as outlined above, complete exploration of the heart and pericardium with control of the bleeding is a matter of some urgency. Blood transfusion during the operation is essential as further bleeding may be considerable before control is achieved. An antero-lateral thoracotomy through the fourth space gives adequate access; the side chosen will depend on the site of injury. Bleeding vessels in the pericardium can be ligated and lacerations of the cardiac muscle should be carefully sutured. All blood should be removed from both the pleural and pericardial sacs. The latter should not be sutured completely, in order to allow any effusion to escape into the pleura. The pleural cavity should be temporarily drained. (*See* Heart and Pericardium, Vol. 4, p. 424.)

(2) Foreign bodies

Radiography

Foreign bodies may be situated near the pericardium, in the pericardial sac, in the heart muscle, or in one of the chambers or great vessels. They probably occur more frequently than is generally realized as they can easily be overlooked on routine radiography. Penetrating, oblique or lateral films are necessary to demonstrate them. Careful screen examination is essential for accurate localization. The dangers of cardiac or pericardial foreign bodies lie in the liability (1) to lead to embolism either of the foreign body itself or of an associated thrombus; (2) of bacterial endocarditis, myocarditis or pericarditis; (3) of recurrent pericardial effusions; and (4) to precipitate myocardial rupture or hernia.

Removal of foreign bodies

The pros and cons for removal must be carefully weighed in each case bearing in mind the symptoms and position of the foreign body and also the psychological effect on the patient. Removal of foreign bodies both from the walls of the heart and from its chambers and associated large vessels was successfully carried out by Harken (1946) during World War II and he convincingly demonstrated that the operation was not only technically possible but devoid of undue risk (Harken and Zoll, 1946).

5. THORACO-ABDOMINAL WOUNDS

The diaphragm may be injured by foreign bodies passing from the thorax to the abdomen or *vice versa*, or by crushing injuries which may rupture the diaphragm and result in the development of a hernia.

In assessing thoraco-abdominal wounds the following facts should be elucidated whenever possible.

(1) The actual track of the missile and its final destination.

(2) The nature and extent of injuries, both above and below the diaphragm.

(1) Indications for operation

The indications for operation are:

(1) Extensive injury of chest wall or lung which would merit thoracotomy on its own account.

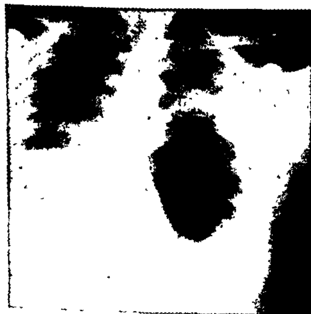
(2) Any actual or suspected injury to a hollow abdominal viscus.

(3) Injury to a solid abdominal viscus associated with signs of persistent bleeding or peritoneal irritation or one in which large foreign bodies are present.

(4) Involvement of the kidney.



(a)



(b)

FIG 87.—Thoraco-abdominal wound with early development of an obstructed diaphragmatic hernia. P-A films (a) 24 hours after sustaining a penetrating wound of chest The foreign body lies in the chest wall. Appearances are those of a raised diaphragm Conservative policy adopted; (b) 10 days later, after onset of persistent vomiting, showing very dilated stomach in chest. Uneventful convalescence after thoracotomy and repair of the hernia

(2) Contra-indications

Cases which may not require early operation are injuries due to a small missile with involvement of a solid viscus and no sign of severe intrathoracic damage or persistent bleeding. Such cases should be treated conservatively by aspiration of any associated haemothorax.

(3) Exploration

If exploration is thought desirable the surgeon should set out and be prepared to deal with all aspects of the injury both above and below the diaphragm. Wounds of the parietes should be adequately dealt with and rib fragments removed. *Abdomen* In the abdomen, perforations should be sutured or excised according to accepted principles; foreign bodies should be removed if readily located and lacerations of solid viscera repaired when practicable. *Diaphragm* The diaphragm should be repaired with interrupted sutures of non-absorbable material and the muscle should be temporarily paralysed. *Chest* In the chest the pleura should be cleared of blood and clot and lung lacerations sutured or resected.

The approach

The approach will largely depend upon the familiarity of the surgeon with the compartment concerned, but generally speaking a thoracic or combined approach is to be preferred because: (1) the abdominal injuries can easily be treated from the chest; and (2) the thoracic injuries can only be adequately inspected and treated from the chest.

Each case will, however, have to be judged on its merits.

(4) Complications

The most frequent complications below the diaphragm are: (a) subphrenic abscess; (b) liver abscess; (c) diaphragmatic hernia either early or late (Fig. 87); and (d) pleuro-biliary fistula (Blackburn and d'Abreu, 1945).

6. INJURIES TO THE MEDIASTINAL STRUCTURES

The grosser forms of trauma affecting the mediastinum may produce injuries incompatible with survival, yet the surprising thing about missiles which traverse the midline is the relative infrequency with which the important structures are damaged.

(1) Oesophagus

The most important organ which may be involved from the point of view of early treatment is the oesophagus. Injuries seem more prone to occur near the thoracic inlet than elsewhere, but any portion may be involved. Reconstruction of the path taken by the missile may lead one to suspect an oesophageal injury. *Symptoms* Symptoms are due to mediastinitis producing severe toxaemic changes, difficult and painful swallowing, difficult respiration and effusions of thin infected fluid often containing food particles in one or both pleural cavities. Surgical emphysema in the mediastinum or at the root of the neck

may be discovered. Smaller perforations may lead to a localized mediastinal abscess. Skiagrams may show a fluid level or bubbles of air in the mediastinum or a mediastinal widening. The diagnosis should be confirmed by giving the patient a little barium to swallow and observing its passage on the screen. *Diagnosis*

Treatment

Treatment in the earlier stages (that is, in the first few days after injury) should consist of a formal thoracotomy with repair of the oesophageal laceration. In later cases with a localized abscess, drainage of this should be effected by posterior mediastinotomy or, if high up in the thoracic inlet, it can be approached from the neck. Persistence of an oesophageal fistula after such drainage may necessitate exploration and repair. Temporary gastrostomy may encourage adequate healing.

(2) The larger bronchi

These bronchi are occasionally torn or completely severed by crushing injuries. The resulting disturbances are often surprisingly slight, consisting essentially of persistent atelectasis of lobe or lung. Such cases will soon demand bronchoscopic examination, when the true state of affairs will be revealed. In the early stages, repair of the bronchus may be a practicable procedure, but if the condition is discovered later or if infective changes have occurred in the lung distal to the lesion, resection is the only possible treatment. *Bronchoscopy*

(3) The great vessels

Severe injury to the great vessels will almost certainly lead to uncontrollable haemorrhage. Less severe damage may produce an arteriovenous aneurysm or fistula.

(4) The thoracic duct

An injury to the thoracic duct leads to the accumulation of chyle in the pleural cavity. This should be aspirated regularly but if re-accumulation persists, thoracotomy will be required owing to the rapid deterioration of the patient.

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THROMBOSIS AND EMBOLISM

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324.] Clotting of blood and thrombosis are vital phenomena which come into play at short intervals and are necessary for survival. These processes appear early in the development of animal life and without them races would not exist.

1. FUNCTIONS OF CLOTTING AND THROMBOSIS

Prevention of blood loss

Extravascular clotting of blood is an emergency measure required to stem the flow of blood under many conditions. Minor or major lacerations, subcutaneous injuries, fractures and so on are accompanied by haemorrhage, and without the extravascular clotting of blood the individual could be exsanguinated from any minor injury. When a vessel is opened the ejected blood at the periphery of the gash very quickly begins to clot by reason of its mixture with thrombokinase and also because of the disturbance set up in the platelets as a result of the escape of blood from its natural pressure and environment. This clotting process rapidly develops through the mass of shed blood until it closes in to smother the end of the open vessel, much as a fog closes in to envelop a lighthouse. The psychological response of all wounded creatures, including man, is to assume a position of rest which places the exposed vessel and the blood clot under conditions whereby the encroachment by the clot on the vessel will be most effective. Under reasonably good conditions, this thickening gel of blood smothers the end of the vessel until, with the lowering of blood-pressure, and with the constriction of the vessel and the increased resistance to the flow because of this gel, the clotting process will enter the end of the open vessel and the haemorrhage is stemmed. Surgeons might be classified as good or bad, depending on their ability to appreciate, and to effect, the conditions which will promote the most successful means of controlling the loss of blood.

Clotting within vascular tree

As an occasional subsidiary to extravascular clotting and under adverse conditions as a result of intravascular injuries or conditions that have produced injury or thrombosis in vessels, clotting may take place within

the vascular tree, but this is an abnormal phenomenon. In its normal role, clotting takes place in blood that is stagnant, in the sense that it is not included in the circulating volume of the individual.

The next process, which is probably of more significance in relation to complications in surgery, is that of thrombosis. This phenomenon takes place only in the presence of circulating blood and is concerned with the provision made for the repair of the intima of the vascular system under normal working conditions, and these efforts are redoubled when the repair of pathological conditions of vessels is required. *Thrombosis of circulating blood*

One can picture the platelets, which are the active bodies involved in this process, being constantly on the watch for minor or major changes in the intima of blood-vessels. As minor injuries from ordinary stress, strain and pressure appear on the intimal surfaces, the platelets are ever in attendance, as is the repair gang repairing the cracks in the pavement of the highway. Instead of tar being poured into the cracks, the minor injuries in the intima are filled with platelets which have small pseudopodia by which they attach themselves and lay down a smooth surface, filling the chinks and crevices. Their function has to do only with repair of intima and the restoration of those surfaces necessary for the smooth circulation of blood. If this process goes out of control so that the repair is inadequate, or under some conditions is excessive, the results may be disastrous, and especially is this the case when clotting is added to the process. As has been demonstrated experimentally, the clots become endothelialized within a very short space of time, the lining of the vessel becomes smooth again, and the circulation goes on unimpaired *Repair of intima*

These are the functions of the two systems of clotting and thrombosis, taking part in the active, healthy, everyday life of all animal creatures and promoting the health and well-being of the individual. Under unusual conditions, the normal working of the two systems may be changed, and one of the commonest conditions under which such an upset occurs is that related to operative surgery. The normal rate of flow, the blood-pressure and the condition of intimal surfaces, may be, and usually are all changed, and other upsetting influences are also introduced. Anaesthetics are toxic. Frequently the patients are suffering from disease which has upset the consistency and constituents of the blood, and the function of the liver, kidneys and other organs which are involved in the processes of clotting and thrombosis. It is the purpose, therefore, of this article, to examine some of the conditions which tend to upset these natural phenomena and as a result of which abnormal thrombosis or clotting takes place; to examine methods that may be applied to prevent such changes; to consider what may be done in the way of treatment once these upsetting influences have been put into action; and to consider methods of treatment of the disastrous results that ensue under such conditions. *Upset of functions*

2. SURGICAL OPERATIONS

When a surgical operation is undertaken, a normal or good response in these repair mechanisms is necessary for recovery and survival. Substances introduced to provide anaesthesia in any form upset the normal functions *Effect anaesth*

of the body but if well controlled the patient can recover and effect satisfactory repair. If, however, the derangement is carried beyond a certain point, irreparable damage may ensue. Under certain conditions the blood becomes incoagulable and there is an irreversible change from which the experimental animal does not recover. It is doubtful how closely these conditions may be matched in human patients, but it is certain that the more nearly the tissues and physiology of the patient approach the normal, the better are the prospects of recovering from the many effects of the injury induced by anaesthesia and operation.

Before an operation is undertaken, therefore, very careful consideration must be given to whether the patient's physiology as regards his vascular system is in a state to make it possible to repair the damage which may result from the anaesthetic, the operation and the post-operative period. The patient with severe liver damage, severe kidney disease or interference with many other important functions may not be able to effect the necessary repair following major procedures. In doubtful cases some indication of deficiencies may be given by a knowledge of liver and kidney functions, of the state of the blood in the way of the health and proportion of the cellular elements and platelets, the normal relationship and concentration of proteins and their level, including prothrombin, and by the bleeding and clotting times, as well as the capillary resistance test.

Liver and kidney functions

(1) Impairment of function

The conditions which are apt to cause changes in the blood in this respect are chronic liver diseases, kidney diseases, congenital or acquired diseases such as haemophilia, thrombocytopenic purpura, some liver diseases in which the proportion of blood proteins is changed, and acute or chronic nutritional disturbances which, in some patients, eventually may interfere with the normal blood clotting and thrombosing processes. Certain diseases which affect the blood-forming organs and interfere with the production of cells, as in anaemias and the leukaemias, may interfere with these functions.

(i) *Due to loss of blood.*—A great loss of blood at operation precipitates striking changes in the blood and vascular tree which may interfere disastrously with the normal repair process and may precipitate unusual responses in these functions

(ii) *Due to changes in the vascular tree.*—Changes in the vascular tree itself may be very important: the changing of normal responses to those which are pathological, may end in disaster. At operation, either by handling or by incision and dissection, blood-vessels are invariably injured and, even though larger vessels are dealt with or tied off, the end-process in the repair of these is one of clotting and thrombosis at the site of injury. Usually this limits itself to the operative field and should not be progressive, being controlled by conditions which tend to limit this process within a segment of the vessel in which there is stasis. But under adverse conditions the process, once initiated, may extend widely throughout the vascular tree and precipitate disastrous results such as extensive thrombosis and embolism. The thrombosis may involve vessels that are vital and may [illegible] function of important organs such as the kidneys. The surgeon's

Spread of thrombosis

objective, therefore, is to deal with the vascular system in such a way as to limit the amount of such reaction. The minimal number of vessels should be divided. The fewer vessels that require ligation the better, this is the proper approach to any operation. It is an advantage when only the smaller and terminal vessels require to be dealt with, and the larger trunks and branches should be avoided. Of course the field of surgery in which there is a direct attack on the larger trunks is another matter, and the method of dealing with these vessels must be such that the minimal tendency to clotting and thrombosis is produced. Again, it is the surgeon's responsibility to prevent a loss of blood which would reduce blood-pressure or change the consistency of blood sufficiently to precipitate the extension or propagation of thrombosis or clotting. *Aim of surgeon*

(iii) *Due to interference with rate of flow.*—The consistency of plasma and the specific gravity and size of the cellular elements in blood have been developed to travel at a speed which has a fairly wide variation. The blood is conducted through tubes, with angles and bifurcations, in such a way that these elements provide sufficient resistance and protection for the cells, and injury is not done, either to the walls of the vessels or to the flowing blood within. Once can imagine a red cell, a leucocyte and a platelet rushing down the axial stream of a large vessel surrounded by a layer of fluid plasma which, as it were, greases the intima and promotes smooth transit for these large numbers of cells. As they approach the bifurcations and branches of vessels, as they do momentarily throughout their course, they are not dashed against the bifurcation, because of the consistency of the plasma which is able to float these cells so that they do not come directly into contact with the intima. Consequently the intima is preserved and protected from the bombardment of these solid elements. Because the organism requires certain oxygenation and nutrition and flushing of tissues in all areas, the rate of flow through the oxygenating mechanism, as well as through the final distributing centres, is adjusted, as is the fluid medium between floating and fixed cells, to provide a healthy interchange for all cells in the organism. Any alteration, therefore, of this rate of flow beyond its normal limits will impair the health of the functional fixed tissue-cells throughout the organism. If the rate of flow is slowed, the cells awaiting the next consignment of oxygen may be in want before the oxygen-carrying cells arrive. If, on the other hand, the number of oxygenating cells has been reduced by haemorrhage, the amount of oxygen available, even perhaps with an increased rate of flow, may be inadequate, and the efficiency and health of these cells is impaired to a greater or lesser degree. *Function of plasma*

(2) Influence of operative measures

This finely balanced system of distribution and supply is upset by various diseases and toxins, but it is especially disturbed by the preparation and the preliminary medication for operative measures, by the operation and by post-operative care, so that the patient's convalescence probably is not complete until these finely balanced mechanisms have been again restored to normal with all toxins and poisons washed away and disposed of, and a

complete repair of all damaged tissue effected. If the dose of preliminary sedative before anaesthesia is too heavy and the patient too greatly depressed thereby, the mechanism of clotting and thrombosis is thrown out of balance to an extent which cannot be predicted with accuracy. As soon as anaesthesia is introduced, the anaesthetic agent again interferes with the mechanism.

Sedatives

Position of patient

The patient be may kept lying in a cramped or unnatural position for many hours during prolonged operation, during which segments of the circulation may be compressed or interfered with, and the general circulation also may be upset by toxic effects. The patient may have to be placed in the high Trendenburg position and kept there for some hours, which in itself may cause a very serious injury even in a normal person. When the chest is opened at operation, the adequacy of positive ventilation is an important matter in order to ensure adequate oxygenation of the tissues as a whole. The limitation of respiratory activity by various forms of anaesthesia, including spinal anaesthesia, must be overcome to the utmost and great care should be taken to select the form of anaesthesia which will interfere least with these mechanisms.

Shock

Of the many forms of injury, there is probably none to equal the potent influence of a single stroke by the surgeon, if perchance the latter has not the ability to prevent excessive loss of blood. If it should happen that the loss of blood is unavoidable, then the surgeon should make provision so that replacement is adequate, in order that the patient will not suffer from the consequences of the blood loss. While shock on the operation table may occur from many other sources, the commonest and the most disastrous is that resulting from haemorrhage. Although it produces a variety of effects in surgery, the one with which we are interested, namely clotting and thrombosis, is seriously affected. A change in the consistency of blood, the rate of flow, and the resulting fall in blood-pressure, profoundly affect the tendency to clotting and thrombosis, as well as the health of organs involved in the exercise of this function.

If, when blood-pressure is low, the patient is also strapped in an awkward position, the danger of precipitating thrombosis at some remote point in the vascular tree is quite considerable. If the legs are tied down to support the weight of the body there is the danger of initiating thrombosis or clotting in the region of the foot or calf. Once this process has been started, a patient who for any reason has depleted resources, is not in a condition to limit it to a small area, and it may become a spreading and widespread process, with the resulting dangers.

Limitation of exercise

When the patient is returned to bed, if too heavily sedated, or in shock, the tendency is to lie for hours in an awkward position, during which time the process of clotting and thrombosis is apt to be initiated, especially when there is a depression of blood-pressure, or a diminution of blood volume. On recovering from anaesthesia, the pain of incision and manipulation may limit the normal exercise of extremities, chest or abdomen and interfere with the normal course of circulation through these regions. Not until the patient is energetic, is moving about actively, is out of bed and has restored the volume, rate and tone of circulation to normal, are the dangers of thrombosis passed. Indeed, even the normal, healthy individual may on occasions develop thrombosis or clotting in the vascular tree, but

once the patient has returned to normal activity, probably the responsibility of the operation and of the surgeon has passed.

3. TREATMENT

(1) Preventive

Methods of prevention are far superior to any method of trying to control the situation once thrombosis has occurred, and, with that in mind, the careful selection of patients for operation, and appropriate treatment preceding, during and following operation, are essential. Early rising is a great advantage in that it tends to restore the circulation to its normal flow and will bring into activity the outlying areas of circulation in the extremities. There are, however, patients, especially the aged, who cannot be treated in this way. In these cases it is an excellent plan to exercise the extremities, to apply massage, and to elevate the foot of the bed following operation so that stagnation in peripheral vessels is avoided and the tendency to clotting is thereby diminished. Deep-breathing exercises encourage the rate of return flow to the heart and improve the circulation as a whole, as well as improving oxygenation. *Early rising*

With the ever-present fear of post-operative thrombosis and embolism, a great many efforts have been made to reduce this by undertaking active treatment. In the author's early work on heparin (Murray, 1947a) it was suggested that it might be an advantage, with such a good anticoagulant, to administer this prophylactically in all patients, either before, and in any case after, operation. It was disappointing, however, to find that the cost of this substance was too great to use as a routine measure in every post-operative patient. It was at this point that dicoumarol seemed to fill the gap, but this is too toxic and its effects are too uncertain to permit of its indiscriminate use. The dosage should be adjusted to raise the prothrombin time to about double the normal, and this must be checked daily, or every second day at most, with prothrombin estimations by an experienced technician. Allen (1947) has decided that, as most pulmonary embolisms came from the lower extremities, ligation of the femoral vein on each side immediately after operation would eliminate these dangers, and more than 2,000 such operations have been done with a relatively low incidence of pulmonary embolism. However, it has been the author's experience (Murray, 1940) that the ligation of major vessels may be the exciting factor in precipitating thrombosis, because all such ligations must heal by thrombosis and clotting, and whether this remains limited to this area or extends more widely through the vascular tree is again accidental. Also there have been some deaths as the result of venous ligation, and for that reason, while the efforts have demonstrated some improvement, they have not completely eliminated embolism. *Heparin* *Dicoumarol* *Ligation of femoral vein*

If patients are selected carefully enough, if sound judgement on the part of the physician and surgeon is exercised so that patients who are not likely to be benefited by operation are not interfered with, and if great care is exercised throughout and following operation, the incidence of embolism can be reduced to a minimum. In spite of all precautions, a few cases of pulmonary embolism will occur and it seems to be impossible at present to *Selection of patients*

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THYMUS GLAND

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1. GENERAL PRINCIPLES

325.] The removal of the thymus gland is a comparatively recent development of thoracic surgery. Tumours of the thymus gland are uncommon, and many *Tumours* of them are not amenable to surgery. By far the largest number of operations done today on the thymus gland are done with a view to the removal of the gland, or of a tumour arising in it, from patients with the clinical signs and symptoms of myasthenia gravis. The first successful removal of a thymic tumour of this kind was done in 1936 by Blalock of Baltimore (Blalock and his colleagues, 1939) and in 1941 the same surgeon initiated the routine removal of the thymus gland, although no tumour was present (Blalock and his colleagues, 1941). Since that time, a large number of operations have been performed in Great Britain and the results, though erratic, have been on the whole satisfactory (Keynes, 1946).

The operation of thymectomy is based on two assumptions.

(1) That the thymus is an endocrine gland of which the normal function is unknown.

(2) That it may undergo a pathological change, and in consequence, produce an abnormal secretion which interferes with the action of acetylcholine at the neuromuscular junctions, resulting in the clinical condition known as myasthenia gravis.

Total removal of the gland does not produce any undesirable side-effect, *Removal of gland* but frequently it results in the cure or improvement of patients with myasthenia gravis.

Myasthenia gravis may occur at any age from infancy to the sixth decade, and, although the prognosis is more favourable in the younger patients, there are very few who are to be regarded as hopeless. Clearly, it is unwise to *Conditions for operation* operate on patients who are so ill with myasthenia gravis and pulmonary complications that any operation is almost certain to be fatal. Patients over

50 years of age are also unlikely to benefit. Except in these circumstances, there are few reasons for withholding operation from myasthenic patients. Even those who have the disease to a mild degree should not necessarily be excluded, since the condition is commonly progressive.

2. ANATOMY

The thymus gland is a bilobed organ lying in the potential space known as the anterior mediastinum. Each lobe consists of an upper cornu reaching almost, or quite, to the isthmus of the thyroid gland, and a wider, more solid body, which usually spreads out below to become attached to the pericardium.

Appearance and shape

The gland is smooth, encapsulated and pinkish-yellow in colour. Its general shape is that of a flattened pear, with an elongated stalk. The two lobes are sometimes separate, but are more often fused together for a variable distance

Size of gland

in the midline. The gland, as a whole, is relatively large in the infant, but is absolutely largest about puberty; after puberty it regresses slowly, and by the fifth decade it is often largely replaced by fatty tissue. Its average weight in adolescents and adults suffering from myasthenia gravis is 15 grammes, and this is probably about the same in normal individuals.

The thymus gland lies immediately behind the manubrium sterni and the body of the sternum; it is separated from the bone by connective tissue and, to a variable extent, in its lower half by the medial edges of the lungs and

Upper cornua

pleural membranes. The upper cornua extend into the neck beneath the sternothyroid and sternohyoid muscles above the suprasternal notch.

Laterally, the body of the gland is covered by the lungs and pleura. Behind the gland there are, from above downwards, the trachea, the left innominate vein, the aorta and the pericardium. In about $2\frac{1}{2}$ per cent of cases, one or both lobes lie behind the left innominate vein instead of in front. The two lobes are applied to the surface of the aorta and accommodate themselves to its convexity.

Blood supply

The main arterial blood supply reaches the lateral borders of the gland by vessels coming obliquely downwards and inwards from the direction of the inferior thyroid arteries. Blood-vessels also accompany the upper cornua

Venous drainage

where they meet the thyroid isthmus. The venous drainage is formed by a vein lying on the back of each lobe. These veins usually unite to form one large vessel passing to the anterior surface of the left innominate vein; sometimes they enter the innominate vein separately. The lower ends of the lobes, although they may be firmly attached to the pericardium, have no vascular connexions below.

3. PRINCIPLES OF OPERATION

Since the thymus gland is centrally placed in the mediastinum, the most

Approach and exposure

direct approach and the best exposure are obtained by dividing the sternum in the midline. This approach has the added advantage that it usually avoids doing any injury to the pleura, a very important consideration in dealing with myasthenic patients.

Extent of incision

Although the gland extends from the thyroid isthmus to the pericardium, it is not necessary to make the external opening for the whole of this extent.

The upper end of the approach need not pass more than ¾ inch above the suprasternal notch, since a horizontal incision at this level allows retraction of tissues to a higher level. Neither need the lower end expose the whole of the lower part of the gland, which can be detached from the pericardium while part of it is still behind the sternum. The sternum is, therefore, divided only to the level of the third or the fourth costal cartilages according to the length of the chest. Conservatism is to be observed in the surgical approach, in order to preserve the integrity of the thoracic box, and so, also, of the respiratory mechanism. Myasthenic patients are often severely handicapped in this respect by their muscular weakness, and their chief danger lies in respiratory failure.

4. THE OPERATION

(1) Anaesthesia

The anaesthetic should be given by an experienced administrator who can maintain quiet respiration with a closed circuit and assume complete control of the movements of the lungs. In order to avoid irritation of the trachea an endotracheal tube must never be used.

Premedication is effected by an injection of Omnopon, ⅓ grain, and scopolamine, $\frac{1}{150}$ grain, given half an hour beforehand. *Premedication*

Induction is by the intravenous injection of Pentothal Sodium. Anaesthesia is maintained by cyclopropane and oxygen. Ether should not be used.

(2) Position of patient

The patient lies supine with the head extended. It is advantageous to raise the shoulders on a Dunhill "thyroid bridge" or on a sand-bag, so that the thorax is brought forward. The table may be sloped downwards or kept flat according to the shape of the chest (Fig. 88). *"Thyroid bridge"*

(3) Infiltration of subcutaneous layers

The skin above the suprasternal notch and in the midline of the sternum is infiltrated with a solution of adrenaline in normal saline (1:250,000) to discourage superficial oozing.

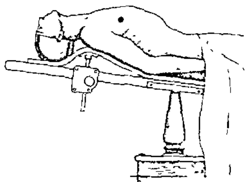


FIG. 88.—The position of the patient for thymectomy.

(4) Operative technique

A horizontal incision, 3–4 inches long, is made ¾ inch above the suprasternal notch; a vertical incision is then made downwards from the centre of this to the level of the third or fourth costal cartilage, dividing all the tissues down to the bone (Fig. 89). The upper end of the incision is deepened between the insertions of the pre-tracheal muscles and a finger is introduced behind the sternum to separate connective tissue and muscles from the back of the bone as far down as possible. The ligament crossing the suprasternal notch is next *Incisions*

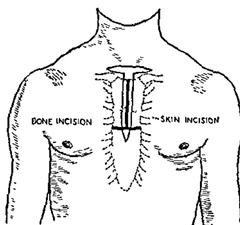


FIG. 89.—Diagram to show the positions of skin and bone incisions for thymectomy.

divided, together with a blood-vessel which usually lies in front of it. The second or third intercostal space is then cleared on either side with a rugine, and a blunt dissector is passed upwards through each space in turn. This instrument is made to meet a finger introduced from above to ensure that neither pleural membrane is likely to be injured.

Division of sternum

The sternum is now divided horizontally from one intercostal space to the other by means of a Lebsche chisel (Fig. 90 (a)), and then vertically in the midline by means of a Sauerbruch sternum splitter (Fig. 90 (b)). This procedure may need some force, but it should be effected without injury to the pleura. If there is much bleeding from the cut edges of the sternum, this may be controlled by pressing small lumps of

Control of bleeding

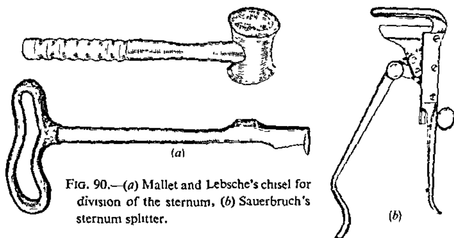


FIG. 90.—(*a*) Mallet and Lebsche's chisel for division of the sternum. (*b*) Sauerbruch's sternum splitter.

Horsley's wax into the bone. A strong self-retaining retractor is then inserted, and the two halves of the sternum are separated, the lungs and pleura being pushed to either side with gauze.

Division of connective tissue

The connective tissue covering the thymus gland is now divided in the midline and is then peeled to either side with toothless dissecting forceps. The pleura is soon reached at the sides and is similarly pushed away without injury. The lateral blood-vessels are clamped and ligated as they are encountered (Fig. 91).

Cornua

The upper cornua of the gland are defined, and clamped and divided where they meet the thyroid isthmus. The accompanying vessels are ligated. The cornua can now be turned downwards, and the upper parts of the lobes are separated from the surface of the left innominate vein. The vein or veins draining the gland are identified, divided between clamps, and ligated. The rest of the gland can then be separated with the finger from the front and sides of the aorta, and is finally peeled from the surface of the pericardium. It is at this point that the pleura is in the greatest danger of injury; and great

Division of veins

Danger of injury to pleura

care must be used. If a hole is made, it may sometimes be closed by a ligature.
The thymus is now free and can be removed (Fig. 92).

The retractor is removed, and the two halves of the sternum are approximated by allowing the patient's shoulders to be pushed forwards on the

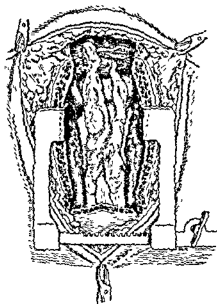


FIG. 91.—The thymus gland defined by dissection. The drawing shows the two main arteries to the gland

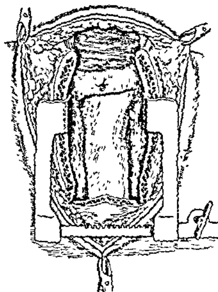


FIG. 92.—Drawing of the mediastinum after removal of the thymus gland, showing the pericardium below, with the aorta and the innominate vein. The thymic vein has been ligated

[illegible] of the sternum, and wiring of the bone is unnecessary. [illegible] fatty layers are united with fine catgut and the skin incision is closed. The

Closure of incision

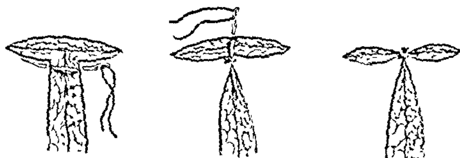


FIG. 93.—Diagrams to show the method of suturing the skin incision.

mediastinum is not drained. Union of the skin at the junction of the horizontal and vertical incisions can be effected by the device shown in Fig. 93.

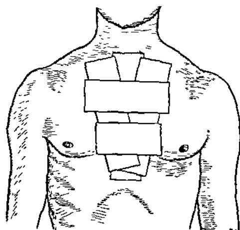


Fig. 94.—The method of applying the dressing after thymectomy so as not to interfere with respiration

(5) Precautions

The wound is covered with gauze and then with Elastoplast applied longitudinally, so that there is no interference with the respiratory movements of the chest (Fig 94)

The patient is given an injection of 1 milligram of Prostigmin during the last stage of the operation to promote efficient respiration and coughing as consciousness is regained.

5. PRE-OPERATIVE AND POST-OPERATIVE CARE

(1) Pre-operative measures

Diagnosis

Assuming that the diagnosis of myasthenia gravis has been fully established, usually by noting the patient's response to Prostigmin, it remains to record accurately the various signs and symptoms that are present after Prostigmin has been withheld for about 12 hours. This serves as a basis for comparison of the patient's condition as the result of the operation becomes established. The maximal dose of Prostigmin that the patient needs is then ascertained by trial, and is kept at this level for a few days. Meanwhile, the patient is drilled in deep breathing and forced coughing with a view to the post-operative period.

Basis for comparison

A careful x-ray examination is made in order to exclude, if possible, a thymic tumour. Thymic tumours occur in 10 per cent of patients coming for operation, and are a contra-indication to primary operation, since better results are obtained after preliminary deep x-ray therapy. The tumours can usually be seen lying in the lower part of the anterior mediastinum, both in antero-posterior views and in lateral views of the thorax.

Contra-indications for operation

Any sign of respiratory infection is another important reason for postponing operation. The patient should, if possible, be isolated, and the nursing staff and visitors should wear masks during the pre-operative and post-operative periods, in order to minimize the risk of infection.

Respiratory infections

Myasthenic patients should not be given enemas, which may produce alarming syncope.

(2) Post-operative treatment

After operation the Prostigmin dosage should be temporarily increased, and for a few days the deep breathing and coughing drill should be enforced at hourly intervals when the patient is awake. If all goes well, the Prostigmin can be progressively reduced according to the patient's needs. The time needed to establish the result of the operation is very variable. Some patients feel the benefit almost at once, and may be able to do without Prostigmin in a fortnight. In other cases, the effect may spread itself over weeks or months.

If there has been any question of injury to the pleura, the thorax must be

x-rayed, and it is, indeed, best to do this as a routine. If there is any pneumothorax the air must be removed at once by repeated aspiration until the lung is fully expanded.

Examination of thorax

Any sign of respiratory infection must be treated at once with large doses of penicillin. Extra fluids and all intravenous therapy are to be avoided, since there is less tendency to the secretion of mucus in the respiratory passages if the patient is kept "dry". This secretion is sometimes profuse, and is one of the great dangers of the post-operative period.

Secretion of mucus

The patient may be kept lying flat on the back for the first few hours after operation, but should then be sloped comfortably on pillows. If there are no complications, the patient may often be allowed to get out of bed in a fortnight, though it should be remembered that a myasthenic patient does not immediately regain full use of the muscles, even though Prostigmin is not needed. A varying amount of re-training may be necessary.

6. RESULTS OF THYMECTOMY

Mortality

The operative mortality following thymectomy was high while experience was small. With greater experience, however, the mortality rate fell to a low level, and in 100 consecutive operations on patients who did not have thymic tumours, only 4 patients have died, all as the result of respiratory infections. Experience in the preparation and post-operative care of the patient, as well as in operative technique, has been the determining factor for the patient's safety.

The long-term results of operation in 84 patients who did not have thymic tumours have been established in the following way.

Category	Condition	Percentage
A	[illegible]	31
B	[illegible]	32
C	[illegible]	26
D	[illegible] change	11

Thymic tumours

The results in patients with thymic tumours are extremely bad, at least after a primary operation. Improvement may be rapid at first, but it tends to be followed by relapse and death in the course of a few weeks. The operation risk is also much increased, since injury to the pleura is almost inevitable unless the tumour is in a very early stage. It seems probable that results will be improved if a course of accurate deep x-ray therapy is given before operation is attempted.

It may be said, in general, that the best results will be obtained in the younger patients with the shorter histories, and that the prognosis worsens as age advances. In addition, the result in any given patient can never be predicted with confidence, so that promises should not be asked or given. There are pleasant surprises as well as bitter disappointments.

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[References to other titles are given under Thymus Gland in the Index Volume.]

THYROGLOSSAL CYST, SINUS AND FISTULA

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1. INTRODUCTION

326.] Thyroglossal cysts occur in the path followed by the developing thyroid gland in its descent from the base of the tongue. The thyroglossal tract is lined by epithelium and a little lymphoid tissue is associated with it. Normally when the thyroid gland reaches its permanent position, the tract disintegrates and disappears.

Cyst — Rarely some epithelial cells persist and form a cyst containing mucus secreted by minute glands which have been demonstrated in the cyst wall. If development of the thyroid gland has failed or has been imperfect the epithelium may proliferate and form thyroid gland tissue.

Sinus — Less commonly a sinus remains, opening either at the site of the foramen caecum or on to the skin of the neck. The rarest abnormality is a complete

Fistula — fistula extending from the foramen caecum to the surface of the neck.

2. ANATOMY

Descent of the thyroid gland precedes the laying down of the cartilage from which the hyoid bone is formed. Because of this the tract may in different cases appear to be ventral or dorsal to the hyoid bone, or to perforate it. This point has been discussed by Frazer (1925), Keith, Parsons and others. It is certain that the bone is in close relationship with the tract and may become adherent to it. Frazer has shown that the developing bone about the third month of foetal life may push forwards and downwards into the tract causing it to make a shaped curve almost encircling the waist of the bone (Fig. 95). Failure to appreciate this relationship is the chief cause of recurrence after operation.

Chief cause of recurrence

Location of cyst — A cyst may occur at any point along the tract from the foramen caecum to the thyroid isthmus, but is found below the hyoid bone much more frequently than above it. It usually overlies the thyrohyoid membrane. Generally the cyst is centrally placed, but may be pushed to one side (usually

the left) by the developing thyroid cartilage, and thus comes to lie upon the thyroid ala. A stalk can sometimes be felt between the cyst and the hyoid bone. Less frequently a cyst may be found above the hyoid bone, in which case it may protrude in the angle between the neck and the floor of the mouth,

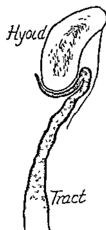


FIG. 95.—Thyroglossal tract pushed downwards and forwards by the developing hyoid bone in the third month of foetal life. The tract partially encircles the bone. (*By courtesy of Brit J. Surg.*)



FIG 96.—Skiagram to show Lipiodol in a patent tract arborizing in the tongue. (*By courtesy of Brit J. Surg.*)

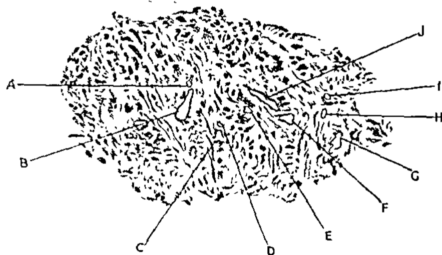


FIG. 97.—Section of tongue removed by "coring" showing the tract cut across in ten places (*By courtesy of Brit. J Surg*)

or it may be embedded in the muscles of the base of the tongue Kinsella (1939) has described the tract above the hyoid bone branching widely in arborescent fashion in the muscles of the tongue (Fig. 96), and the tortuous

thin and it moulds itself into the surrounding and underlying tissues. The stalk will then be defined and in many cases will seem to disappear under the hyoid bone, though, in fact, it may run anterior to it. When there has been inflammation dissection is more difficult, but by leaving a difficult area for the moment and by working around where separation is easier the whole stalk will be cleared.

Division of muscles

The muscles are then divided so as to expose the hyoid bone about half a centimetre on each side of the middle line—the central centimetre of the



FIG 99.—Skiagram showing a pool of iodized oil above the hyoid bone. From a case in which part of the tract had been stripped off with the periosteum and the attached muscle.

bone is to be removed with the cyst. It is wrong to strip the muscles off the middle of the hyoid bone because a portion of the tract may be separated with them and remain in the wound.

Using narrow-bladed bone-cutting forceps the central centimetre of the hyoid bone is removed with the cyst or other remnant of the tract attached, and the specimen is freed by cutting across the muscular and connective tissues above the bone. In a series of 16 cases it has not been necessary to follow the tract up to the foramen caecum. No attempt should be made to suture the remnants of the hyoid bone together in the midline. When haemostasis has been secured a small drain is placed in the wound, which is closed in layers.

Haemostasis

Sistrunk (1928) devised an ingenious method of calculating the direction of the tract above the hyoid bone and coring it out of the tongue in the direction of the foramen caecum. It is doubtful, however, whether this is necessary for the majority of cases in which recurrence might have occurred after the older type of operation, and also whether it would achieve its purpose if the tract branches in arborescent fashion in the tongue (Figs. 96 and 97), since the "coring" would fail to embrace the ramifications of the tract.

When a recurrence takes place after an inadequate operation a skiagram taken after an injection of iodized oil shows a pool of the oil immediately above the hyoid bone (Fig 99). A glance at Fig. 95 shows that if the muscle attachments are stripped from the mid portion of the hyoid bone with a periosteal elevator a portion of the tract is almost certain to be left behind, and recurrence is then inevitable. To avoid this a few millimetres of muscle should be left attached to the bone and removed with it, together with the cyst or sinus. In the two recurrences in this series this was done at a second operation and was followed by complete cure. There has not been a recurrence since this procedure has been followed. It seems unnecessary to submit every patient to the "coring" operation when 16 patients have been cured by removing a little of the muscles attached to the hyoid bone.

Limits of tract

It would seem that the tract very rarely reaches the foramen caecum. Even when it does the top end may not require removal, for the sinus which remains discharges harmlessly into the mouth.

Kinsella's appears to be the only case reported to date in which a complete tubular fistula from tongue to neck has been treated by operation. The tract was permeable to iodized oil throughout. It was dissected from below up to the digastric muscle and was ligated there. The lower end of the fistula was removed, the neck wound has remained healed, and the opening at the foramen caecum causes no inconvenience to the patient.

8. RESULTS

In a series of 16 operations none of the wounds has failed to heal after removal of the centre of the hyoid bone with the muscles attached to it

Alteration of the voice or difficulty in swallowing has never been encountered after operation.

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[References to other titles are given under Thyroglossal Cyst, Sinus and Fistula in the Index Volume.]

THYROID GLAND—DISEASES OF

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1. INTRODUCTION

327.] There has never been any doubt about the value of surgery in non-toxic goitre causing pressure, but it was not until the first decade of this century that its importance in the treatment of thyrotoxicosis was described by a number of surgeons. For example, Mayo (1907) reported on 110 operations, with 9 deaths, but with very pleasing results in the survivors; Kocher (1909) reported on 200 cases with a mortality of 4 5 per cent, and 85 per cent of satisfactory results; and, finally, Dunhill (1907, 1908, 1909, 1910), at that time a young surgeon in Melbourne, published accounts of a series of 199 operations for severe thyrotoxicosis with only 3 deaths, despite the fact that, in his view, "scarcely any case was too advanced to stand operation or too ill to benefit from it". Joll (1932) has emphasized Dunhill's precedence as the advocate of extensive bilateral resections, but of at least equal importance is the fact that the success of his operative work, and that of other pioneers in this field, created confidence in the surgical cure of thyrotoxicosis. *Value of surgery* *Successful operative work*

The success of thyroid surgery depends upon the skill of the surgeon and, as there are many places which lack surgeons of adequate calibre, it is to be hoped that recent biochemical advances will continue until a medical cure for this disease is discovered.

2. CLASSIFICATION

It is very difficult to devise a satisfactory classification of diseases of the thyroid gland and yet an attempt to do so must be made in order to simplify the task of diagnosis and treatment. As the aetiology of the majority of types of goitre is unknown, and as the pathological appearances are often difficult to correlate with the clinical picture, it is not possible to base a classification upon either of these grounds. Anatomical and physiological classifications are unsatisfactory to the clinician, with the result that a compromise arrangement, partly clinical, partly physiological, partly pathological and partly *Clinical classification*

anatomical, is usually employed. In such a classification the diseases of the thyroid gland of surgical interest are grouped in some such manner as the following.

(a) Simple goitre, small or large, epidemic or sporadic.
(b) Nodular goitre, non-toxic or toxic.
(c) Exophthalmic goitre or Graves's disease.
(d) Infections and neoplasms.

Intermediate and transitional types

The difficulties associated with such a classification are, first, that there are many cases intermediate in type which cannot be fitted into any of these groups and, secondly, that the clinical picture of many thyroid cases change with the passage of time. Thus, the smooth colloid goitre common in the twenties may become nodular in the thirties and toxic in the forties, to quote only one of a number of transitions which are described (Means, 1937).

Treatment classification

If these classification troubles should prove mortifying to the surgeon's sense of academic propriety, he can console himself with the thought that he is concerned with only a limited number of diseases of the thyroid gland and, in these, mainly with the question of treatment. It appears reasonable, therefore, to classify from the point of view of treatment, those thyroid states commonly seen by the surgeon. Paradoxically enough, it is necessary to begin with a group in which surgical treatment is not indicated, because small, simple goitres occurring about the age of puberty are often brought to a surgeon for advice. Apart from this group, which is included to remind surgeons that it is not necessary to operate upon such patients, there is a large section embracing unsightly goitres, smooth or nodular enlargements causing pressure, those exhibiting signs of thyrotoxicosis, and small nodular goitres which may not be producing pressure or poisoning when seen, but in which there is a definite risk of malignant degeneration or thyroid poisoning. All these are included in the classification under the heading "Indications for subtotal resection" (p. 261). Finally, there is a section labelled "Indications for total resection" (p. 264), which contains operable malignant disease of the thyroid, and a section on "Indications for local removal", for single benign adenomas if diagnosed accurately at operation (*see* Table).

TABLE

CLASSIFICATION

TYPE OF OPERATION	CHIEF CLINICAL FEATURES	TYPE OF THYROID
Operation contra-indicated	Full neck, no thyroid dysfunction	Small simple or colloid goitre
Subtotal thyroid resection	(*a*) Unsightly swelling (*b*) Pressure (*c*) Thyrotoxicosis (*d*) Risk of malignant change	Any type of large prominent goitre All large smooth or nodular goitres All toxic goitres, whether smooth or nodular, with or without demonstrable thyroid enlargement, with or without exophthalmos All nodular goitres whether large or small
Total thyroid resection	Signs of invasion and fixity of gland	Operable malignant disease of thyroid
Local resection	Usually single nodule in gland	Benign true adenoma if accurately diagnosed

This "treatment" classification is in effect also a creed which may be repeated by all thyroid surgeons, with no more mental reservations than those commonly made by reciters of creeds and which, on suitable occasions, may well be followed by a commination of some vulgar errors in regard to goitre (Linnell, Keynes and Piercy, 1946).

3. ANATOMY

Variations from the normal anatomy, as described in any good text-book, are commonly found when nodules develop in relation to the thyroid vessels and nerves. As these nodules grow, the point of entry of the arteries may be displaced in any direction. In the same way, the recurrent nerve may be displaced and thus become more exposed to injury at operation (Hertzler, 1935). *Displacements of vessels and nerves*

Thyroid tissue is occasionally found lateral to the gland in relation to the carotid vessels. The name "lateral aberrant thyroid" has been given to this variation from the normal It is of surgical significance owing to the frequent development of carcinoma in it (Dunhill, 1931) Single or multiple tumours of this type occur in approximately 1 of every 500 cases of goitre (Lahey and Ficarra, 1946). *Aberrant thyroids*

4. PHYSIOLOGY AND BIOCHEMISTRY

The chief function of the thyroid gland is to manufacture thyroxine from iodine and tyrosine, store this hormone, and liberate it as required to regulate the metabolism of the body. The ductless glands generally form a closely integrated system. For example, there is a relationship between the thyroid and the ovary, shown not only by the swelling of the former gland at puberty and during pregnancy, but also by the association of a lymphadenoid goitre with loss of ovarian function (Parmley and Hellwig, 1946). Apart from this general ductless gland relationship, there is a special link described as the thyroid-pituitary axis (Salter, 1940). It appears that, as a result of stimuli received from the nervous system *via* the hypothalamus, the anterior lobe of the pituitary gland secretes a thyrotrophic or thyroid-stimulating hormone (called T.S.H. for short) which regulates the rate of secretion of thyroxine. But thyroxine is an antagonist to the thyrotrophic hormone, so that normally there is a balanced reciprocal arrangement, which is disturbed in diseased conditions. *Integration of all ductless glands* *Thyroid-pituitary axis*

5. MORBID ANATOMY

Simple or colloid goitre may be sporadic or endemic and is due mainly to an absolute or relative lack of iodine. There is an initial hyperplasia followed by accumulation of colloid producing a smooth swelling of the gland, such as is often noted at the age of puberty. It may retrogress and never reappear, or a smooth enlargement may persist, but the most common sequel is the development of areas of hyperplasia and of involution irregularly scattered through the gland leading to localized accumulations of colloid, more or less separated from the gland proper by fibrous septa. The lumps thus formed are usually multiple, may vary in size and may undergo degenerative changes such as cyst formation, calcification or malignant degeneration. They are known as *Simple goitre* *Involution nodules*

involution nodules and are not true tumours. Goitres of this type commonly become toxic sooner or later, but it may be difficult to correlate this change with signs of increased cellular activity in the gland (Fig. 100).

Graves's disease

In Graves's disease, on the other hand, the typical pathological appearances include marked hyperplasia, increased vascularity and a moderate-sized smooth goitre, but here again correlation between pathological and clinical signs may be difficult, as for example, when the clinical picture of Graves's disease is associated with a nodular goitre.

True adenoma

True adenomas of the thyroid are encapsulated tumours and are usually single.

Carcinoma of the thyroid

Carcinoma of the thyroid gland occurs in three main types, scirrhus or carcinoma simplex, papilliferous adenocarcinoma and malignant adenoma. The most common by far is the malignant adenoma, which comprises from 85 per cent to 90 per cent of thyroid carcinomas (Dunhill, 1931). It usually arises from a pre-existing nodule—a statement not to be dismissed lightly, for it has been found (Cole, Slaughter and Rossiter, 1945) that 25 per cent of true adenomas, 17·1 per cent of non-toxic and 1·7 per cent of toxic involution nodules undergo malignant change. There is one reservation necessary when considering the statistical results of treatment of malignant disease of the thyroid gland, namely the criteria of malignancy adopted. Cases in which there is macroscopic invasion of surrounding structures give no difficulty, but those in which the diagnosis has been made microscopically may be misleading because of the difficulty of determining the onset of malignant change. In the latter group, undoubted invasion of vessels by the growth must be demonstrated before a diagnosis of malignancy can be made.

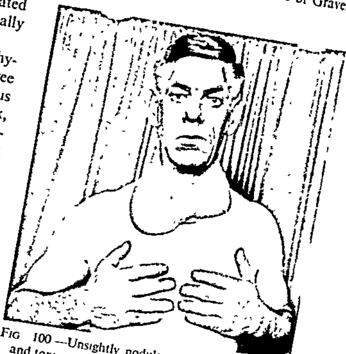


FIG 100—Unsightly nodular goitre causing pressure and toxic signs (mainly cardiac) and predisposing the patient to the risk of malignancy. Note that acromegaly was also present in this patient, as is not uncommon. The goitre weighed 4½ lb.

6. CLINICAL PICTURE

It is usual to describe the clinical picture in terms of typical groups, such as simple or colloid goitre, both small and large, nodular goitre with or without toxic signs, and smooth hyperplasia of the gland with exophthalmos. This ime-honoured custom disregards the chameleon-like behaviour of these oitres which change in clinical type as the years go by and also fails to

emphasize the frequency of intermediate types. For this reason the clinical picture will be arranged in accordance with the "treatment" classification already given, emphasis being placed rather upon the general signs and symptoms of thyroid pressure, thyroid toxicity, and so on than upon the typical appearances of either Graves's disease, or other classic syndromes found in thyroid disturbance. *Method of description*

(1) Contra-indications to operative treatment

Adolescents exhibiting a slight fullness of the neck without any signs of thyroid dysfunction are frequently brought to a surgeon for advice because, particularly in a goitre-conscious community, some busybody has noticed the fullness and said, "Oh, that is a goitre. You must have it seen to." The alarm thus produced may have been increased by futile attempts at medical treatment. Many such goitres, particularly in males, retrogress later, but the fact that some become nodular is no justification for advising a prophylactic operation for this type of goitre. *Small, simple or colloid goitre*

(2) Indications for subtotal resection

Subtotal resection is indicated for an unsightly goitre, for a goitre causing pressure, for thyrotoxicosis, whether or not there is a palpable goitre, and for nodules which may undergo malignant degeneration or may become toxic.

(a) *Deformity*

A large goitre bulging outwards from the base of the neck may be very unsightly. It is better to remove it than to allow the patient's life to be made miserable by the rude stares of those who pass by. *Unsightliness*

(b) *Pressure*

The major incidence of pressure is upon the trachea, which may be displaced, distorted and compressed, with the result that air entry is impeded and there is dyspnoea on exertion. If the goitre grows downwards into the mediastinum, pressure signs are increased and, in such cases, it is usual to find distended veins on the chest and neck. In advanced cases there may be stridor. Palsy of a recurrent laryngeal nerve is common and must be detected *pre-operatively by a laryngeal examination of every patient.* Pressure upon the oesophagus is rarely significant, though it is not unusual for patients to complain of dysphagia because they are aware of the lump in the neck. *Tracheal compression* *Distended veins* *Recurrent nerve palsy*

Naturally, pressure signs are most common in large goitres of the nodular type. Occasionally a large smooth colloid goitre is found and, in 1 per cent of patients, the stony hard gland found in both types of chronic thyroiditis is responsible.

(c) *Thyrotoxicosis*

The onset of thyrotoxicosis may be acute or insidious but generally extends over a few months. The clinical picture is that associated with an increased metabolic rate—the patient feels the heat but not the cold, loses weight despite an increased appetite, is nervous and sweats easily, complains of dyspnoea on exertion and is easily fatigued, suffers from a fine muscle tremor and, finally, bursts into tears at the slightest provocation. The *Onset* *Clinical picture*

menstrual flow is usually diminished. The patient's family looks harassed because of constant "nagging". Acute exacerbations of the disease, known as crises, are not uncommon, the symptoms being predominantly nervous, cardiovascular or gastro-intestinal, or a mixture of all three (McArthur and her co-workers, 1947).

In addition to this picture, certain aspects of the disease require discussion in detail, as follows.

Auricular fibrillation

(i) *Cardiovascular abnormalities.*—Gross arrhythmias are common, notably auricular fibrillation, which occurs in paroxysms before becoming established and leading to congestive failure. Extrasystoles, auricular flutter and paroxysmal tachycardia also occur. The pulse rate and the pulse pressure are raised. Permanent myocardial damage may follow long-continued thyrotoxicosis.

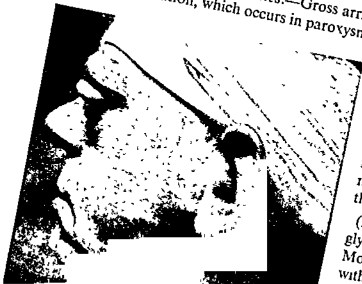


FIG. 101.—Progressive exophthalmos after subtotal thyroid resection. The right eye was removed because of infection following a corneal ulcer. The patient was treated prior to the introduction of the Naffziger operation.

Association with diabetes

(ii) *Glycosuria.*–Transient glycosuria is common. More marked glycosuria with blood sugar curves resembling diabetes mellitus occurred in 5 per cent of a series of 450 severe cases of thyrotoxicosis. Of these, 1 per cent were not



FIG. 102.—Unilateral exophthalmos associated with thyrotoxicosis without obvious thyroid enlargement

restored to normal after operation and therefore must be regarded as cases of *true diabetes mellitus*, but even in the presence of this disease, subtotal resection is followed by improvement and is therefore indicated (Newton, 1938).

(iii) *Exophthalmos.*—The immediate cause of this condition is a swelling of the extraglobar orbital contents, particularly the extrinsic orbital muscles. These muscles weaken and thus become unable to counter the forward push of the tissue pressure in the orbital cavity (Mainini, 1942). The ultimate cause of these local changes is not clear, but it appears probable that the thyrotrophic hormone plays an important part in their production and that, here again, thyroxine is its antagonist. If there is an excess of thyrotrophic hormone in the presence of a hypofunctioning thyroid gland, the stage is set for the development of a progressive exophthalmos (Fig. 101). In other words the surgeon must realize that there may be pronounced exophthalmos without thyrotoxicosis and that, in such cases, operation on the thyroid gland is contra-indicated (Means, 1944). Exophthalmos is occasionally unilateral (Fig. 102). It is always unsightly and may endanger vision by the development of corneal ulceration.

Changes in orbit

Action of thyrotrophic hormone

(iv) *Psychoses.*—It is often difficult to determine whether mental derangement is due to, or merely associated with, thyrotoxicosis. In the latter case, the condition may become worse after operation and it therefore behoves the surgeon to investigate the mental condition thoroughly before giving a prognosis of the post-operative outlook.

(v) *Skin diseases.*—Pruritus, pigmentation, leucodermia and various rashes have been described, but the most distressing skin complication is a solid oedema of the subcutaneous tissue of the legs causing deformity. The cause is not yet known and there is, at present, no effective treatment.

Oedema causing deformity

(vi) *Hepatic damage.*—In severe thyrotoxicosis there is an impairment of liver function and, in view of this fact, estimation of the galactose tolerance and the hippuric acid test are sometimes employed diagnostically but are not reliable (Maxwell, 1947).

(vii) *Myasthenia.*—A condition amounting to a true muscle dystrophy is not uncommon in neglected cases of thyrotoxicosis, and various muscle endurance tests have been devised as aids in diagnosis of thyrotoxicosis. The weakness disappears after operative treatment (Lahey, 1947).

(viii) *Thyrotoxicosis in the male.*—There is a greater incidence of cardiac arrhythmia in males and usually the signs are more severe, doubtless because, being the breadwinner, the male thyrotoxic patient delays seeking advice.

(ix) *Thyrotoxicosis in children.*—Though rare, the clinical picture of the disease in children is similar to that in adults, but, as the gland is essential for growth, operation is reserved for severe cases, and, in children, more gland is left *in situ* after resection than in the adult.

(x) *Variations from the usual clinical picture.*—The clinical picture is often incomplete. For example, there may be an increase in weight due to over-compensation by appetite; the pulse may be slow, not fast; in short, the surgeon must be prepared to find one or other of the cardinal symptoms lacking.

Increase in weight, slow pulse

Then again, there are two well-known syndromes, namely, Graves's disease (or primary thyrotoxicosis) [illegible]

exhibit a smooth enlargement of the gland in which a thrill can be det and in whom exophthalmos is common; and Plummer's syndrom secondary thyrotoxicosis), which is found typically in older people a associated with a nodular gland and predominantly cardiac signs and sy toms There are also many cases intermediate in type. Thus exophthalm may develop in an older patient who has a nodular goitre, and may be abse in a younger patient who exhibits all the other signs of primary toxic goitr Marked evidence of thyrotoxicosis may be observed without thyroid enlarge ment. In short, thyrotoxicosis is a single disease in which the differences, though often striking, are of degree and not of kind (Dunhill, 1930).

Atypical intermediate cases

Thyrotoxicosis without a goitre

(*d*) *Nodular goitre without pressure or thyrotoxicosis*

Small nodular goitres may become malignant or toxic. There is no effective medical means of prevention of these complications, therefore it is desirable to advise operative removal in all patients suffering from nodular goitre. For this reason the phrase "all nodular goitres whether large or small" was included in the indications for subtotal resection in the Table.

Malignant tumours

(3) Indications for total resection

Malignant disease of the thyroid, if operable, demands total resection of the gland. In most instances the disease begins in a pre-existent nodule. The con-sequent enlargement passes unobserved with the result that, when first se by the surgeon, there is often a large fixed growth associated with voi change and pressure signs. Signs of thyrotoxicosis are unusual. These growth metastasize early and the prognosis, even after complete removal of the gland and after radiotherapy, is, at the best, prolongation of life rather than cure. Recently, a small, partly calcified thyroid nodule, which a doctor had observed unchanged in his neck for 20 years, became malignant, spread like wildfire and caused death in 3 months. It is not necessary to see many such cases to become a convert to the belief that all thyroid nodules should be removed.

Benign tumours

(4) Indications for local removal

Local removal is adequate in a benign true adenoma of the thyroid gland provided that there is no sign of malignant change. These adenomas are often present in children as a small lump the size of a pea, which subsequently enlarges and may cause pressure signs or thyrotoxicosis. The difficulty is to recognize at operation that the lump is a true adenoma. The writer thought that he could do this during the twenties of this centur but found, during the thirties, that in half the cases he had overlooked tir involution nodules, had removed a large nodule under the belief that it wa a true adenoma, and was faced with the mortifying task of performing a subtotal resection at a second operation.

7. DIAGNOSIS

Insidious onset

The diagnosis is simple in the case of a large goitre with pressure signs or when there is well-marked thyrotoxicosis. When the onset of thyroid poisoning is insidious, there may be little more than loss of weight for some months

and the true diagnosis may not be made until after the development of other symptoms of thyrotoxicosis.

The importance of a small thyroid nodule as the cause of auricular fibrillation and congestive failure is sometimes overlooked. Finally, a patient who exhibits a small simple goitre associated with an anxiety state may be wrongly diagnosed as suffering from thyrotoxicosis. There is little excuse for mistakes in the first two groups quoted but, in the "anxiety-state" type, the use of diagnostic aids is frequently necessary. If still in doubt, further delay in advising surgery is preferable to performing an unnecessary thyroid resection. In such cases there is no harm in waiting.

Thyrocardiac type

Simple goitre with anxiety state

8. DIAGNOSTIC AIDS

Estimation of serum iodine (Winkler and his co-workers, 1946) or, better still, of the clearance rate of iodine from the gland by using a Geiger counter after the administration of radio-active iodine (Rawson and McArthur, 1947) should soon be in general use for the determination of hyperthyroidism. A single estimation of the basal metabolic rate is useless, but the general trend of multiple estimations may be of some value. If the equipment required for these tests is lacking, then administration of iodine and thiouracil may be used as a clinical test. A remission will usually occur if thyrotoxicosis is present.

Serum iodine

Rate of iodine clearance

Basal metabolic rate

9. TREATMENT

(1) Surgery

The "treatment" classification (*see* p. 258) clearly indicates that surgical removal holds pride of place in the treatment of all surgical diseases of the thyroid gland. There can be no argument about this when it is necessary to relieve pressure or to remove an unsightly goitre but, in so far as thyrotoxicosis is concerned, it must be emphasized that almost any treatment is better than bad surgery. The mortality rate following operation for all types of thyrotoxicosis has steadily fallen and is now about 0·5 per cent in skilled hands. But thyroid surgery is not easy, as is shown by the fact that the operative mortality rate of a surgical staff of varying degrees of skill and experience, working under conditions existing in a public hospital, remains at about 3 per cent or 4 per cent. There is every reason, therefore, to encourage biochemists and physicians to make great efforts to improve medical methods of treatment, so that these may be substituted for surgery in places where, owing to unskilled surgery or poor conditions, the operative mortality is more than 0·5 per cent.

Mortality rate

(2) Thiourea and similar drugs

Thiourea was introduced by Astwood (1943) but has now been replaced by other drugs of the same group, namely, thiouracil and its methyl and propyl derivatives. These drugs act by restricting the synthesis of thyroxine, the natural antagonist to the production of thyrotrophic hormone, and also by reactivating this hormone by a reductive mechanism (Albert and his co-workers, 1946, 1947) (Fig. 103). The reduction in thyroxine synthesis produces a remission in the signs and symptoms of thyrotoxicosis, but the increase

exhibit a smooth enlargement of the gland in which a thrill can be detected and in whom exophthalmos is common; and Plummer's syndrome (secondary thyrotoxicosis), which is found typically in older people and is associated with a nodular gland and predominantly cardiac signs and symptoms. There are also many cases intermediate in type. Thus exophthalmos may develop in an older patient who has a nodular goitre, and may be absent in a younger patient who exhibits all the other signs of primary toxic goitre. Marked evidence of thyrotoxicosis may be observed without thyroid enlargement. In short, thyrotoxicosis is a single disease in which the differences, though often striking, are of degree and not of kind (Dunhill, 1930).

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Mortality rate

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in the amount of thyrotrophic hormone makes the hyperplasic thyrotoxic gland still more hyperplasic, friable and vascular, thereby increasing the technical difficulties should operation be necessary. In addition to making

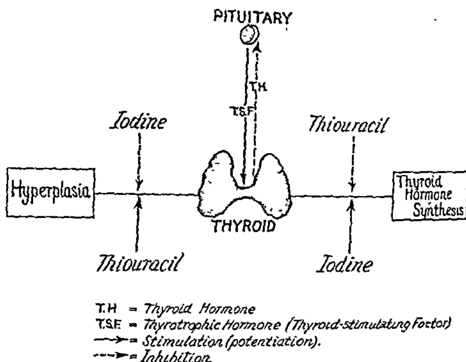


FIG 103.—Diagram to show the opposing actions of the thyroid-stimulating hormone and thyroxine

Effect of drugs on gland

Swelling

the gland mushy, these drugs may make it swell. They should not be administered, therefore, to patients suffering from nodular goitres of a size which suggests that a little additional swelling may cause great pressure effects. No surgeon of experience should be unable to cope with a friable gland resembling those of the pre-iodine period, but he has every justification for annoyance if he is presented with a patient at the point of suffocation owing to injudicious administration of thiouracil. Finally, these drugs produce toxic reactions of various types. The incidence of these reactions after thiouracil is 13 per cent, but this percentage may be lowered after further experience with propyl-thiouracil. The death rate from malignant agranulocytosis is 0·5 per cent (American Council on Pharmacy and Chemistry, 1946).

Toxic reactions

Other toxic reactions include leucopenia, granulocytopenia, drug fever and skin eruptions. On the other hand, a prolonged, and in some cases, a permanent remission may follow the use of these drugs, particularly after they have been exhibited for some months, a statement which must be qualified at once by indicating that the recurrence rate after cessation of treatment is very high.

(3) Thiouracil and iodine therapy

Action of iodine

Iodine given alone rapidly produces a remission of thyrotoxicosis in the great majority of patients, but does not cure this disease, and its use should be confined to the pre-operative period. But the simultaneous administration

of iodine and thiouracil is of value not only pre-operatively but also as a method of treatment (Maxwell, Gunter and Schwarz, 1946). The two drugs act in opposite ways. The action of thiouracil is described above; that of iodine is twofold, because, in addition to its iodinating action in the production of thyroxine, it has a separate involuting effect which is at least partly due to the inactivation by oxidation of thyrotrophic hormone (Wright and Trikojus, 1946). This involuting effect removes the technical difficulties caused by the action on the thyroid gland of thiouracil alone, and it follows that a course of iodine should always precede operation in patients who have been taking thiouracil or one of its derivatives. *Combined therapy*

It will be obvious from the above that thiouracil, though an important advance in treatment, is not a cure for thyrotoxicosis and that its use is not devoid of danger. Skilled surgery is still preferable to drug treatment alone (Means, 1946), particularly in view of the fact that the use of thiouracil combined with iodine gives a more effective pre-operative preparation than has been available hitherto. If the only alternative is bad surgery, thiouracil and iodine treatment is justifiable, particularly in young patients with small hyperplasic goitres. *Summary*

(4) Radio-active iodine

Treatment with radio-active iodine is still in its infancy but it already seems to be effective in many cases in producing a remission together with a marked reduction in size of the goitre. The risk of a late carcinogenic effect is not yet known.

10. PRE-OPERATIVE PREPARATION

(1) General

Pre-operative preparation differs from that given to any surgical patient only if thyrotoxicosis is present, when special psychical and physical care is essential before and immediately after operation. During this time the patient must be shielded from emotional stress, a task which demands time and patience. The general policy must be that the patient, like the customer, is always right and must be humoured, because fright or anger may provoke a crisis. It is unwise to prepare the patient for operation in a medical ward and then to arrange a transfer to a surgical ward either just before or immediately after operation. Both pre-operative and post-operative care should be in the hands of one man, preferably the surgeon, who must be familiar with the medical aspects of thyrotoxicosis and who must be responsible for selecting the optimum time for operation. The mere prescribing of sedatives is a very poor substitute for a careful psychical preparation by the surgeon which, if properly conducted, will remove a great part of the patient's apprehension and thus diminish the operative risk. *Psychical preparation*

Apart from this psychical treatment, the patient's physical regimen must include an ample diet and complete rest. Drug treatment embraces the administration of sedatives and protection of the liver by administration of vitamins of the B complex and of sugar, but the most important therapy is to suppress the manufacture of new thyroid hormone by giving thiouracil or its equivalent and to inhibit the discharge of thyroid hormone from the *Physical preparation*

Thiouracil and iodine

gland by giving iodine (the dose of thiouracil is 0·2 gramme thrice daily initially, gradually reduced, and of iodine, 5 drops of Lugol's solution thrice daily). The basal metabolic rate can be brought to any level required if this treatment is used skilfully, with the result that patients so prepared are spared a stormy post-operative course.

Apart from this general plan of pre-operative treatment there are some additional measures applicable to various complications, as follows.

(2) Cardiac complications

There is no justification for operation in the presence of congestive failure, which must first be relieved by rest and by the administration of digitalis and diuretics. When auricular fibrillation is established and is associated with a rapid ventricular rate which is distressing to the patient, digitalis may be useful, but the pre-operative administration of quinidine is undesirable (Turnbull, Newton, and MacCallum, 1933).

Quinidine contra-indicated

(3) Glycosuria

Patients in whom glycosuria is a prominent feature must be given a diet of high calorific value, shielded by adequate doses of insulin.

(4) Exophthalmos

If there is any risk of the development of corneal ulceration owing to marked exophthalmos, which may prevent complete closure of the eyelids during sleep, the outer thirds of the eyelids should be united by a tarsorrhaphy operation, under local anaesthesia. Operation is contra-indicated in those rare cases of progressive exophthalmos associated with thyroid hypofunction. In such cases, which, by the way, have also been noted after thiouracil therapy, improvement may follow the administration of thyroid extract (Means, 1944), but, if there is real risk of damage to the eye, decompression of the orbit should be performed (Naffziger and Jones, 1932).

Tarsorrhaphy

11. OPTIMAL TIME FOR OPERATION

Generally speaking, it is desirable to avoid a prolonged stay in hospital prior to operation, as this tends to make the patient restless. In uncomplicated cases in which pre-operative therapy has been begun prior to admission, the patient should be ready for operation in 7 days. Valuable clinical signs that this time has arrived are a fall in the rate of the "sleeping" pulse, a gain in body-weight and the cessation of the habit of sitting bolt upright in bed when the surgeon enters the room on his daily visits. Progressive loss of weight during pre-operative preparation is of evil significance and operation must be postponed until it is overcome.

Clinical signs

Loss of weight

12. ANAESTHESIA

The patient should not be told when the operation is to take place; in other words, it is desirable to "steal" the goitre. The simple method adopted by the writer consists in telling the patient that it is necessary to give some rectal medication. On the following morning, a few ounces of tap water are run

"Stealing" the goitre

into the rectum and breakfast is delayed "in order to permit the drug to act better". Next day, that fixed for the operation, Avertin (in a dose of not more than 0 9 gramme per kilogram of body-weight) is given rectally at the same time as was the tap water on the day before. The patient does not clamour for breakfast, owing to its postponement on the previous day, and soon goes quietly to sleep. The neck is then prepared for operation, the patient is removed to the theatre, and given a general anaesthetic to supplement the Avertin pre-narcosis. The type of general anaesthetic used is not of much significance provided that the anaesthetist keeps the patient light and avoids cyanosis. Open ether is better than nitrous oxide or cyclopropane badly given. Some surgeons prefer local anaesthesia, but this is no more effective and is much more trying to the patient. The Avertin method just described is merciful and arouses feelings of relief and gratitude when consciousness returns. Another advantage of preliminary administration of Avertin is that if endotracheal anaesthesia is required owing to pressure signs, the anaesthesia produced by the Avertin alone is sufficiently deep to permit of the introduction of an endotracheal catheter, thus obviating the risk of spasm.

Avertin pre-narcosis

Open ether

Endotracheal catheter

13. OPERATIVE TECHNIQUE

(1) Standard technique

(a) Position

The neck is dorsiflexed by means of an adjustable rest or a sand-bag placed under the shoulders, and the anaesthetist's field is separated from that of the surgeon by a waterproof sheet, one end of which is tied to the neck just below the level of the occiput by attached tapes and the other end clipped to the screen. Sterile sheets are arranged in the usual way (Fig. 104).



FIG. 104.—Showing position of patient and sterile waterproof sl place prior to application of sterile linen sheets.

(*b*) *Incision*

A "collar" incision is made through the skin, superficial fascia and platysma at such a level that the scar will be just cranial to the inner ends of the clavicles when the head is restored to its normal position. The upper and lower



FIG. 105.—Low collar incision has been made and flaps reflected by stripping deep to platysma muscle with gauze wrapped round the finger.

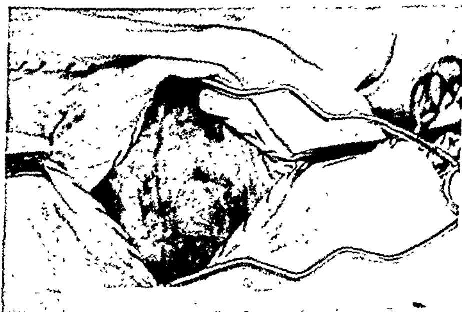


FIG. 106.—Skin packs and self-retaining retractor *in situ*.

Reflection of skin flaps

flaps are separated from the deep fascia in the midline by knife dissection just far enough to expose a plane in which reflection upwards and downwards can be rapidly and bloodlessly accomplished by gauze stripping (Fig. 105). The skin edges are protected by gauze strips and the flaps held apart by a spring self-retaining retractor (Fig. 106).

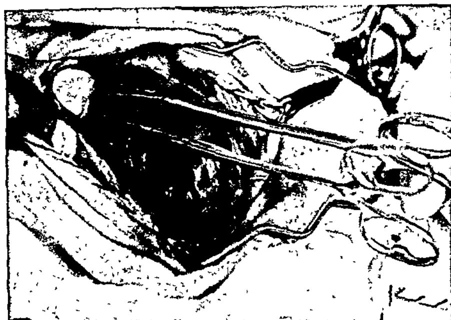


FIG. 107.—The vertical incision has been made between the sternohyoid muscles The inner half of the upper end of the right sternothyroid muscle has been grasped by forceps prior to division. This is not always necessary.



FIG. 108.—Delivery of the right superior pedicle by the finger. The forceps, which is shown behind the pedicle, has been inserted to define its inner border and thus prevent injury to the external laryngeal nerve

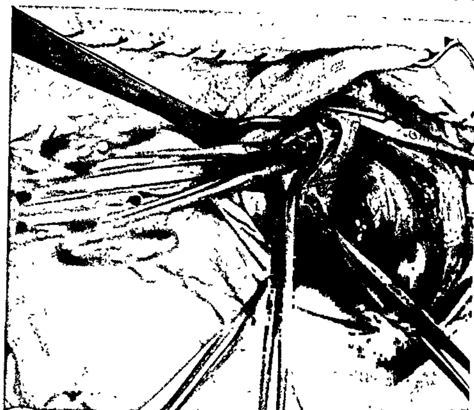


FIG 109.—Showing two forceps applied above and one below the site of division of the superior thyroid vessels After division the cranial end is ligated and the forceps removed.

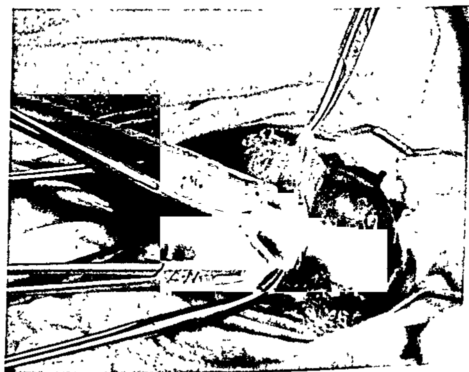


FIG. 110 —Inferior thyroid veins clamped and divided, thus exposing trachea

(c) Exposure of the gland

A vertical midline incision is made between the sternohyoid muscles and extended upwards and downwards as far as necessary to give access to the gland. In very large goitres, the muscle incision may be extended upwards and outwards through its fibres in order to gain adequate access. The plane between the sternohyoid and sternothyroid muscles is separated and the upper fibres of the latter muscle are divided between forceps for one third of their width. This manoeuvre gives easier exposure of the upper pole of the gland and prevents bleeding from branches of the superior thyroid vessels which enter the muscle (Fig. 107).

Muscle incision

(d) The upper pole

The outer border of the upper pole is defined by blunt dissection and the index finger is then passed behind the pole near its apex. Care must be taken not to tear a middle thyroid vein by allowing the finger to stray too far downwards The pole is then hooked forwards by flexing the last joint of the index finger. Care must be taken to deliver with the upper pole any retro-laryngeal extension which may be present. The superior thyroid pedicle is then defined, divided between clamps (Figs. 108 and 109), and size 0 silk or thread ligatures are applied to all divided vessels.

Superior thyroid pedicle



FIG. 111.—Showing middle thyroid vein caught in two forceps and fascia in which it lies, placed on stretch.

(e) The lower pole

The upper pole having been freed and all haemorrhage arrested, the lower pole is delivered and the inferior thyroid veins are defined These are divided between clamps, thus exposing the trachea, which serves as a landmark when the plane of division of the lobe is being selected (Fig. 110). All divided vessels are ligated as before, leaving the area clean and dry.

Exposure of trachea

(f) The inferior thyroid artery and the recurrent laryngeal nerve

The most prominent middle thyroid vein and the fascia in its vicinity are caught between forceps and placed on tension (Fig. 111). Division of this tissue between the forceps exposes a space which can be opened up by gently pushing the finger into it. This exposes the inferior thyroid artery and usually one or more parathyroid bodies may be seen in relation to it. At the inner side of the space the recurrent laryngeal nerve can be felt like a tight wire

Exposure of recurrent nerve

(Lahey, 1938) and is readily exposed by blunt dissection (Fig. 112). The inferior thyroid artery is ligated in continuity.



Fig. 112.—The middle thyroid vein has been divided and the opening thus made in the fascia is enlarged by the surgeon's finger. The inferior thyroid artery and the recurrent laryngeal nerve are easily exposed by blunt dissection. Note that in this case the nerve is passing superficial to the artery.



Fig. 113.—Exposure of nerve entering larynx below cricoid cartilage. The nerve must be exposed throughout its whole extent in total removal of the thyroid gland for carcinoma. Note branching of nerve prior to entry into larynx

(g) *Resection of the lobe*

The main vessels having been secured and the nerve defined, there is no difficulty in cutting across the posterior aspect of the lobe in such a manner that the division on the inner side is on the same plane as the superficial surface of the trachea. The amount left *in situ* on each side must be small. It is far better to remove too much than too little. When a total resection is necessary, it is advisable to expose the nerve up to its entry into the larynx (Fig. 113).

(h) Resection of the opposite lobe

When a subtotal or, if need be, a total resection of one lobe—usually the right—has been completed, and the isthmus separated from the trachea, to which it is closely attached over a small lateral area, the left lobe is resected in the same methodical manner. The only difference in the technique is that it is convenient to remove the pyramidal lobe, if present, after liberating the left upper pole.

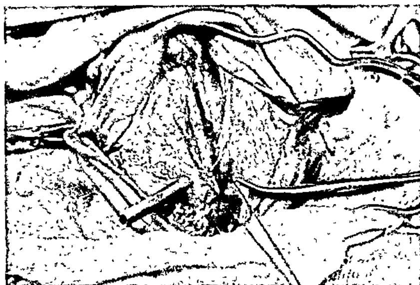


FIG 114 —Depressor muscles sutured and drainage tube *in situ*.

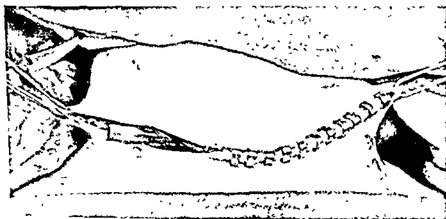


FIG. 115 —Closure of wound by clips Drainage tube brought out through the wound. It is unnecessary to suture the platysma separately

(i) Closure of the wound

The portions of the thyroid gland remaining on each side are sutured with a running mattress stitch; the muscles are brought together; a drain tube is inserted through a buttonhole opening in the muscles and brought out through the lateral end of the incision (Fig. 114) and, finally, the wound is closed by clips (Fig. 115). *Drain tube*

(2) Special operative difficulties

(a) Intrathoracic goitre

Mediastinal extension

When there is a large mediastinal extension of the goitre no attempt must be made to lever it up with the finger. The lobe from which it springs must be freed, leaving the usual small portion posteriorly, after which the extension into the thorax can be delivered by gentle traction on the lobe, the vessels, which enter from above, being clamped as they come into view. If the mediastinal goitre is very large, it may be necessary to scoop out some of its contents to allow it to pass through the inlet to the thorax. The writer has never found it necessary to split the sternum.

(b) Haemorrhage from the superior thyroid artery

If the stump of the superior thyroid artery is lost, it retracts upwards and bleeds furiously. In such a case the muscles of the neck must be freely divided at the upper end of the wound in order to give access to the bleeding vessel.

(c) Haemorrhage from veins

A middle thyroid vein may be torn from the internal jugular vein. In such an event it is safer to tie the internal jugular vein than to trust to a ligature on an inadequate stump of vein entering it. The inferior thyroid veins should be divided as high as possible in the neck and tied at once, lest they retract into the thorax and bleed. Haemorrhage can be arrested temporarily by pressure and the bleeding point seen. Nothing can justify a blind dive into a pool of blood with a forceps in an attempt to stop bleeding.

High division

14. POST-OPERATIVE CARE AND COMPLICATIONS

(1) General directions

Position after operation

After consciousness is regained, the head is raised on pillows to the extent most comfortable for the patient, morphine is given to relieve pain and soft food is given as soon as possible—usually on the evening of the operation day. The tube is removed in 24 hours and all skin clips in 48 hours.

(2) Complications

(a) Haemorrhage

Post-operative haemorrhage

This causes death from suffocation. The wound must be reopened at once to allow the evacuation of the blood and the relief of pressure. This procedure can be done in the patient's bed without further anaesthesia, if the surgeon is gentle and reassuring. The risk of haemorrhage can be greatly decreased by making the patient cough or vomit before the wound is closed at the end of the operation.

(b) Recurrent laryngeal nerve injury

Paralysis of vocal cords

Paralysis of one nerve is a nuisance; paralysis of both is a tragedy, and must be treated by immediate tracheotomy if both cords are adducted. If there is much delay, the bronchial tree is filled with thick mucus and the tracheotomy may be ineffective.

(c) Post-operative crisis

The best treatment is prevention, by skilful pre-operative preparation, wise

selection of the time for operation and operative dexterity. The mortality rate of crises is approximately 75 per cent (McArthur and her co-workers, 1947). When it occurs, continuous oxygen, ample supplies of dextrose and vitamin B, and thiouracil and iodine therapy may be helpful. *Treatment of thyroid storm*

(*d*) *Parathyroid deficiency*

The onset may be marked by typical carpo-pedal spasm or, occasionally by a generalized epileptiform convulsion. If the signs are severe, calcium gluconate (10–30 cubic centimetres) should be given intravenously. Routine treatment consists in the oral administration of calcium chloride (10 cubic centimetres of a 30 per cent solution of the anhydrous salt, freely diluted with water, thrice daily), which provides a high calcium intake while producing the right degree of acidosis (Means, 1937). Thyroid hormone, parathyroid hormone and vitamin D are helpful, but care must be taken to avoid causing a hypercalcaemia. *Treatment of tetany*

(*e*) *Wound infection*

This must be treated as soon as possible with antibiotics as required. In mild cases, sero-purulent fluid may accumulate in the wound and must be aspirated through the line of incision with a sharp needle attached to a 10 cubic centimetre syringe. Spontaneous discharge through the wound may cause an ugly puckered scar. *Antibiotics and aspiration*

15. RESULTS OF SURGICAL TREATMENT OF THYROTOXICOSIS

Proof of the value of any form of treatment comes with the lapse of time, a fact often overlooked by ardent supporters of new methods. The writer has investigated the results of 450 patients suffering from thyrotoxicosis upon whom he had operated from 2 to 9 years previously (Newton, 1938). The series included only those patients in whom there was complete incapacity for work prior to operation. There were 62 males and 388 females, of whom all but 4 were traced. Auricular fibrillation was noted in 23 per cent of the total and, of these, 19 per cent (that is, 20 patients) were suffering from congestive failure on admission. Exophthalmos was present in 48 per cent of the total, glycosuria was a prominent feature in 4 per cent and severe psychoses in 0 8 per cent. *Incidence of severe complications*

(1) Mortality

The operative mortality was 0 6 per cent. Two patients died within 2 months, the first suddenly soon after a normal rhythm had been restored by quinidine; the second, a severe psychotic, committed suicide. In addition, 2 other patients died soon after admission in a state of thyroid crisis. If these 4 non-operative deaths are included, the total mortality is 1·5 per cent. In the writer's last consecutive 1,000 operations for toxic goitre, the mortality was 0 5 per cent.

(2) Post-operative complications

There was 1 case of post-operative haemorrhage; 4 of unilateral, but none of bilateral, nerve injury; and 5 of parathyroid deficiency. Myxoedema of *Myxoedema*

varying degrees was noted in 20 patients but was adequately controlled i all but 3, in whom there seemed to be a mixture of various ductless glan deficiencies. It is far better for the patient to take thyroid daily than to b the victim of persistent thyrotoxicosis (Means, 1937).

(3) Late end-results

There was complete restoration of economic usefulness in 85·7 per cent o patients investigated 4 or more years after operation; partial restoration i 8·3 per cent; bad results in 5·8 per cent (including recurrence of thyrotoxicosi in 1 per cent) and death from other causes in 0·2 per cent. Means (1939) ha commented favourably upon these figures which suggest that, at present surgery offers the best chance of cure of this disease.

I am most indebted to my friend and colleague, Mr. Balcombe Quick, F.R.C.S., wh took the photographs appearing as Figs. 105-115 inclusive, illustrating the steps in th operative removal of the gland. The photographs have not been altered or retouche in any way. I am also most indebted to Dr. L McA Reid, a Research Fellow of the National Health and Medical Research Council, for the help given me in searching the literature and verifying the references.

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[References to other titles are given under Thyroid Gland—Diseases of in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol 5, p 599.]

TONSILLITIS

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1. DEFINITION

"Adenoids"

328] The "tonsil" as popularly known refers to the faucial tonsil, but affections of the pharyngeal tonsil, known when diseased as "adenoids", are so closely related that they must be considered at the same time.

Tonsilloliths

The common causes of complaint are chronic infections. Neoplasms, innocent and, more often, malignant occur but they will not be included in this article. The faucial tonsil is also a lodging place for foreign bodies and it may be the site of calcareous depositions known as tonsilloliths (Weller, 1924).

2. AETIOLOGY

Hypertrophy and recurrent infections of the tonsils are common in childhood, particularly at and after the age of 5 years or so, when there is exposure to prevailing infections by contact with others of the same age and activity

Epidemic sore throat occurs in schools and hospital wards, barracks, ships and similar places where there may be crowding and a heavy air infection from an acute case, or where carriers may involve susceptible contacts. It should be remembered that speech alone will spread droplet infection up to 9 feet from its source (Okell and Elliott, 1936). *Infection by speech*

Sometimes there may seem to be a familial predisposition, but factors of hygiene, environment, nutrition, and climate are probably more important. There is also a possibility that persistence of thumb-sucking, or orthodontic deformity with open bite, may lead to partial mouth-breathing and result in lymphoid hypertrophy (Capps, Gwynne-Evans and Nove, 1945)

In some 2–5 per cent of children, bovine tubercle from infected milk invades the tonsils and spreads to the upper deep cervical lymph glands. *Infected milk*

Certain specific fevers, especially scarlet fever, measles and diphtheria are particularly prone to affect the tonsils In adolescents and adults there may be a persistence of childhood predisposition to infection or intercurrent infection, and to epidemics of septic sore throat At all ages, infections of the nose and sinuses may cause reactionary swelling and infection of the tonsils and adenoids *Fevers* *Infection of nose and sinuses*

3. BACTERIOLOGY

Tonsillar crypts are crowded with pathogenic and non-pathogenic bacteria and in the presence of food and epithelial debris, they act as culture tubes. Fungoid bacteria, so often present, are liable to be associated with a hyperkeratosis and to produce the characteristic pharyngomycosis, a harmless condition which causes distress to the patient by its appearance and may spread beyond the tonsils to the pharyngeal mucosa and the base of the tongue. *Pharyngomycosis*

The streptococci are the most numerous group of organisms found. Although it is stated that haemolytic streptococci are present in a high proportion of throats it is probable that they are only present in any considerable number in acute phases. The work of Thomson and Thomson (1929) suggests that the flora of the throat are constantly changing in the same individual With more accurate serological classification, certain strains of haemolytic streptococci are found to predominate in certain conditions. Pneumococci are also frequent inhabitants of the tonsils. In diphtheria carriers, the bacilli remain in the tonsil or crypts without discomfort to the host and usually removal of the tonsils is the only certain cure. *Causal organisms*

Vincent's angina may cause ulceration and necrosis of the faucial tonsil, and of the chronic infections, tuberculous ulceration and syphilis, in all stages, are known There is now much discussion on the danger of tonsillectomy during a poliomyelitis epidemic, and it is reasonable to suppose that the severing of nerve fibres may open a pathway for the virus In some cases of infective mononucleosis (glandular fever) the lymphoid tissue of Waldeyer's ring undergoes acute hypertrophy. *Vincent's angina* *Poliomyelitis*

4. ANATOMY AND PHYSIOLOGY

Waldeyer's ring

Lymphoid tissue is disposed in a complete ring (Waldeyer's ring) around the upper respiratory and alimentary tract. The faucial or palatine tonsil, lying between the glossopalatine and pharyngopalatine folds (anterior and posterior pillars of the fauces), differs in structure from the rest of the ring. It is encapsulated on its deeper surface and resembles a lymph gland; the faucial surface, however, exhibits a number of pockets or crypts lined with epithelium and open to the pharynx. In this structure may be found, in close relation, all the embryonic layers, epithelial, endothelial, supporting fibrous trabeculae of mesodermal origin, and closely associated muscular tissue. It is not surprising, therefore, to find a great variety of neoplasms involving this structure, although epithelioma is by far the most common.

Variety of neoplasms

The lingual, lateral pharyngeal and pharyngeal tonsils are agglomerations of lymph follicles in the mucous membrane and, except for the last named with its firm relationship to the bony vault of the nasopharynx, they are virtually irremovable.

Lymphoid follicles

Adjacent to the adenoids are the lymphoid follicles in the fossae of Rosenmüller and around the orifices of the Eustachian tubes. These follicles may interfere with the proper functioning of the latter. Recently, they have assumed importance as a possible cause of deafness and have been treated with radium (on intranasal applicators) in order to reduce or to remove them. The pharyngeal lymphoid structures undergo atrophy in old age.

Epithelial covering

The epithelium covering the faucial tonsil and lining its crypts is of the stratified variety; in the nasopharynx it is of the columnar ciliated or respiratory type.

Blood supply

The palatine tonsil has a rich blood supply from the tonsillar and ascending palatine branches of the external maxillary artery, the descending palatine branch of the internal maxillary artery, the ascending pharyngeal and the dorsalis linguae arteries. The tonsil and pharynx, and parts of the palate get their sensory nerve supply from the glossopharyngeal nerve; the associations of this nerve with the auriculo-temporal branch of the fifth nerve, the auricular branch of the vagus, and through its own tympanic branch to the tympanic plexus and Eustachian canal, make pain in the ear a common feature of faucial and pharyngeal affections.

Nerve supply

Lymphatic drainage

Lymphatic drainage is to the anterior upper deep cervical lymphatic glands from the fauces and to the retropharyngeal glands from the pharyngeal tonsil.

Function of tonsils

The function of the tonsils has been a subject for much conjecture. There is no convincing evidence that they produce any enzyme, hormone, essential metabolic substance, internal or external secretion. The significant distribution of the lymphoid ring around the portals of entry of potential inhaled and ingested infection would seem to indicate that their primary function is protective.

Surface absorption

The faucial tonsil has only efferent lymph vessels (Yoffey, 1949) and there is therefore no drainage by afferent lymph channels from the nose, sinuses or neighbouring regions. Any infection is presumably, therefore, by surface absorption.

Ashcroft and Britton (1938-39), after meticulous experiments in which they injected particulate matter and living non-pathogenic bacteria into the antra of

human beings whose tonsils were subsequently removed 24–72 hours later, came to the conclusion that they were not able to confirm results of the animal experiments reported by Griffiths (1937), and that they were unable to adduce direct evidence of the transport of organisms from antrum to tonsil other than by superficial pharyngeal spread.

5. MORBID ANATOMY

Because of the loose cellular structure beneath many areas of the mucosa of the pharynx, acute oedema may become extensive and interfere with respiration and deglutition. Inflammation may be either acute or chronic. *Acute inflammation* In the former, besides the oedema mentioned above, there will be congestion and redness, and there is usually a marked infiltration of polymorphonuclear leucocytes and quite often a fibrino-purulent exudate. With streptococcal infection, this is superficial and easily removed, in diphtheria, however, there *Diphtheria* is necrosis of the epithelium and formation of fibrin, the membrane is adherent and bleeding occurs when it is removed. When the exudate fills the crypts and protrudes from them, tonsillitis is said to be follicular as opposed to the parenchymatous or peritonsillar type of infection. In the latter, peritonsillar abscess or quinsy may develop. Sometimes, quite deep-seated abscesses occur and in the days before chemotherapy and antibiotics, fulminating streptococcal infections have been reported quite frequently as invading the carotid sheath and causing a septic jugular thrombosis (Mosher, 1920).

In chronic infection of the tonsils and adenoids there is often necrosis and *Chronic infection* coalescence of crypts to form cysts filled with leucocytes and cellular debris.

As a result of the breaking down of retropharyngeal glands infected by tonsillar or nasal disease, retropharyngeal abscesses may occur In very small *Retro-pharyngeal abscesses* children this is a more likely complication than peritonsillar abscess. In infancy and childhood, enlargement of the tonsils may represent a physiological response to environment or infection and with appropriate measures the changes are readily reversible It is difficult, clinically, to detect the point at which such a process becomes irreversible and the condition definitely pathological, but this may be suspected when there is a failure to respond to conservative treatment or a change of climate or when there is secondary involvement of the upper deep cervical glands.

6. CLINICAL PICTURE

(1) Acute infections

General constitutional disturbance, with headache, anorexia and shivering, is prominent, particularly in young children. Complaint may be made of pain locally and in the ears which is worse on swallowing, and of tenderness and stiffness of the neck from secondary adenitis. Later the mouth becomes foul and the tongue becomes heavily coated, but may have the characteristic "strawberry" appearance in the scarlatinal type of streptococcal infection. Thick ropy secretion and oedema give rise to a "plummy" type of speech. There may be marked swelling and tenderness of the cervical glands. Trismus is often a prominent feature. Fever is remittent and the pulse rate generally rapid.

Condition of throat

The local condition in the throat varies from slight enlargement and reddening of the faucial tonsils, with a blush on the anterior pillars, to angry, congested, much swollen tonsils, with general oedema of the palate and fauces. Exudate may vary from follicular patches to confluent plaques easily wiped away without bleeding, in contra-distinction to the false membrane of diphtheria. Haemolytic streptococcal infections, particularly the scarlatinal strains, are liable to attack the kidneys, and the urine should be watched, though albumin is usually later in appearance than in diphtheria. The latter must be differentiated from pyogenic infections, the chief points of distinction being the more gradual onset with less fever, less oedema and dysphagia and consequently less trismus, and the fact that it is often unilateral. The false membrane does not remain confined to a definite area such as the tonsil, but spreads to the palate and pharynx.

Differential diagnosis of diphtheria

(2) Chronic tonsillitis

There is no recognized definition of such an entity as a "septic tonsil". *Bacteriology has not helped us to differentiate between the harmless and the* potentially dangerous tonsil. Size is no criterion. Chronic tonsillitis is usually the sequela of one or more acute attacks in which the tonsil tissue, when damaged and infected, fails to return to normal.

Such tonsils remain hypertrophied often with much crypt secretion and, on pressure, sometimes produce gushes of frank pus from a chronic abscess. There is often a persistent enlargement of the tonsillar lymph glands, particularly the single gland of the anterior upper deep cervical group which lies at the junction of the common facial and internal jugular veins and is felt below and behind the angle of the jaw. The pharyngeal wall not infrequently becomes "granular". In young children there is commonly an enlargement of the pharyngeal tonsil with post-nasal obstruction, nasal voice, snoring, and the heavy vacant look which results from the open mouth and inadequate, unrestful sleep. Meals are often protracted affairs owing to obstruction to swallowing and the inability to breathe through the nose *while masticating.*

Enlargement of lymph glands

7. COMPLICATIONS

(1) Acute infections

Quinsy or abscess

In acute infections the commonest complication is a peritonsillar abscess or quinsy. This usually starts after the acute phase has subsided and is a residual infection lodged in the areolar tissue between the upper pole of the capsular surface of the tonsil and the constrictor muscle of the pharynx which forms its bed. Painful swelling with recurrent rise of temperature occurs and, if not aborted, breaks down into a large abscess by about the fifth day, the affected tonsil being dislocated downwards and inwards across the midline. The patient, already debilitated by the primary tonsillitis, is pale, sweating and anxious-looking. Thickness of voice, trismus and dysphagia are more marked than ever.

Infections of ear cleft

Acute cervical adenitis, occasionally with suppuration, is a frequent concomitant. Acute infections of the middle-ear cleft, especially in scarlatinal throats and those associated with measles, should always be suspected if

there is sustained pain in the ears, or if fever and constitutional disturbance is greater than might be expected from the throat alone.

The possibility of joint or cardiac lesions or nephritis as complications must always be borne in mind. The association of acute tonsillitis with the acute rheumatism of children is well established (Kaiser, 1932).

(2) Chronic tonsillitis

Chronic tonsillitis may be responsible for both local and remote effects. Locally, chronic cervical adenitis and persistent middle-ear infection often respond well to removal of infected tonsils and adenoids. Remote effects are bound up with the question of focal sepsis and it is important to get this in proper perspective.

Focal sepsis Horder (1937) says that in focal sepsis few, if any, symptoms are referable to local sites of infection. Yet toxaemia may result in fibrositis, arthritis, anaemia, rarefaction of bone, loss of weight, pyrexia or a combination of these conditions. Pyrexia is not marked in focal sepsis Likely sites are the nose and nasal sinuses, nasopharynx, teeth, and tonsils: chronic infection may lurk in certain of these situations, even when gross macroscopic lesions are absent. Tonsils, when not enlarged, may contain pus or inspissated secretion. A scarred and ragged tonsil, or one bearing venules, is always suspect, especially when a lymph gland is palpable.

Christian (1938) concludes that tonsils and teeth more often serve as a source of focal infection. Earlier belief in the frequency and importance of focal infection to explain many acute and chronic diseases is on the wane. Many are sceptical of this relationship except in a few cases.

Many operations for removal of such foci have been performed with too little consideration of the pros and cons, or as a pure speculation. Yet the frequency with which many departments of all hospitals still refer cases to the ear, nose and throat surgeon for an opinion as to the presence or absence of such a focus, and in cases thought to be positive, request his intervention, leads to the suspicion that success or improvement must be sufficiently common to justify the conception of focal sepsis.

The author, in an article on this subject (Capps, 1940), concluded that the most convincing results are obtained in nephritis and some cases of muscular rheumatism and arthritis. Good results are also obtained in cases of toxic goitre. Results in other conditions are occasional only, and more uncertain. It is important to elicit a history of previous trouble in the tonsils, followed by an attack more definitely associated with the onset of the disease in which they are suspected of complicity.

8. TREATMENT

(1) Acute tonsillitis

The treatment of acute tonsillitis is primarily a medical affair and resolves itself into (a) general, (b) local, and (c) specific measures.

(a) *General treatment*

Isolation, and the treatment of toxaemia, pain, and sleeplessness are the first concern. Fever is a natural reaction and, unless sustained or excessive, does not call for special intervention.

Most cases of acute tonsillitis are highly infectious and should be isolated. If possible a culture should be taken from the throat. To avoid spread, it is important to discover the nature of the infection; when diphtheria is suspected bacteriological examination is imperative. Signs such as vomiting, circumoral pallor and the appearance of a rash within 48 hours may indicate scarlet fever and if the haemolytic streptococcus is isolated it can be grouped for more precise diagnosis. A Gram film of exudate or from the surface of an ulcer may indicate a Vincent infection.

Avoidance of spread

Constitutional disturbance

Toxaemia and even bacteraemia give rise to great constitutional disturbance and are often prominent or major manifestations. Treatment is by rest in bed, a fluid or very light diet, and an initial purge—calomel or a grey powder followed the next morning by a saline purgative is best, combining evacuation with intestinal antisepsis. Fluids are best given in the form of well-sweetened fruit juices. Milky beverages are contra-indicated for they cloy the throat and tend to constipate; if taken, they should be well diluted with water or soda-water. When children will take water only, this is satisfactory.

Fluids

Pain

Aspirin relieves pain generally and, for local relief, it is best given as a suspension in a little mucilage. Being a salicylate it usually has a specific action in these infections. To help the patient to swallow, the ears may be held tightly closed during deglutition.

Sleeplessness

For sleeplessness, aspirin, 10–15 grains, followed by a barbiturate, is often efficacious. Opiates are contra-indicated for they engender constipation.

(b) *Local measures*

Local treatment is of little avail in the acute stage. Antiseptic paints cannot be applied and would probably be of little use. Gargles must pass the spasm of faucial and palatal muscles to be of any value and the pain and effort are usually harmful. The best method of cleansing the throat is to use a very warm solution of bicarbonate of soda or saline and a Higginson's enema syringe. The mouth, fauces, and even the pharynx can be hosed by the patient without much effort and with gratifying relief. A soft woollen scarf, a pad of wool round the neck, plugs of wool in the ears or the application of a fomentation or kaolin poultice is often of great comfort.

When the acute stage has subsided, antiseptic or oxidizing (permanganate, chlorate) gargles or paints (Pigmentum Iodi Compositum or Mandl's paint) may accelerate the devolution of the local condition.

Some combine general and local medication by giving 4-hourly a mixture such as the following.

Liq. Ferr. Perchlor.	5 min.
Liq. Hydrarg Perchlor.	5 min.
Pot. Chloras	5 gr.
Syr. Aurant.	20 min.
Glycer.	60 min.
Aq. Chlorof.	ad 1 oz.

(c) *Specific therapy*

Of late years the sulphonamides and, more recently, penicillin and other antibiotics, have placed powerful agents in our hands. They must, however,

be used with discrimination and the prevalent tendency to use them as a routine is to be deplored.

They should probably be reserved for cases with severe pyrexia and constitutional disturbance or when complications, systemic or local, appear likely to occur.

Sulphonamides The sulphonamides, if given, must be carried to saturation and a full course of 4 or 5 days or more is indicated. Severe relapses, often difficult to control, take place if the drugs are given and discontinued as soon as improvement occurs.

Penicillin Penicillin is now used for so many diverse infections that it is almost true to say that a majority of patients have received it for one thing or another. Two risks occur: (a) the development and predominance of penicillin-resistant flora in mouth, nose and alimentary tract, and a considerable upset in the long established balance of bacteriology of the healthy body; (b) the possibility of a severe allergic reaction on a subsequent administration. It may, indeed, be a tragedy if the life-saving properties of penicillin are required in an emergency and the patient has been rendered allergic by treatment of some previous trivial condition which would have responded well to simple measures.

Local Penicillin can be given locally in the mouth in the form of pastilles containing some 250 units each. They should be tucked in the dento-buccal fold and allowed to dissolve slowly, not sucked or chewed. The essence of success is continuous concentration.

Systemic In severe conditions, penicillin should be administered systemically. Here again, continuous concentration is required but usually an adequate dose is 250,000 units morning and evening or a single daily dose of 500,000–1,000,000 units of procaine penicillin. It should be continued for some days after the initial symptoms subside or relapse may occur.

Antitoxins In diphtheria, the earliest possible administration of antitoxin is indicated and in cases which are clinically very suspicious it should be given without waiting for bacteriological confirmation of the diagnosis. In cases of Vincent's ulceration, the ulcers should be painted with 20 per cent chromic acid at frequent intervals, even daily, until healing occurs.

Cases of infective mononucleosis with severe pharyngeal lymphoid hypertrophy respond to very large concentrations of penicillin administered systemically.

(*d*) *Treatment of complications*

Complications occurring systemically are usually matters for a physician. Locally, peritonsillar or retropharyngeal abscesses are the most likely. These may abort, especially if treated early by a sulphonamide or penicillin but, when an abscess forms, it may either rupture spontaneously or require opening. The latter procedure should be within the competence of every practitioner but at the same time calls for some skill and dexterity. A toxic patient suffering severe pain and usually with marked trismus does not find it easy to co-operate. General anaesthesia is contra-indicated as a large and usually very foul abscess may rupture during induction and flood the airway. When the opening cannot be made without an anaesthetic this should be administered under ideal conditions, with the head of the table lowered and suction apparatus available. Induction should be quiet; gas, oxygen and perhaps a

General anaesthesia contra-indicated

little chloroform being best. Plain nitrous oxide or intravenous anaesthesia should be avoided at all costs; pure chloroform dropped slowly on to an open mask is better and safer by far than either of these.

Local anaesthesia

Local anaesthesia is of little value in acutely inflamed throats and the abscess in most cases can be opened with the patient sitting up in front of the operator without any anaesthetic at all. The head should be well supported by a head-rest or by an assistant and the throat is illuminated by a headlamp or light reflected from a forehead mirror. A right-angled metal spatula is inserted between the incisor teeth and gently worked on to the back of the tongue. At this stage the patient usually opens the mouth involuntarily and the abscess must be quickly opened. The traditional weapon was a scalpel guarded for all but the distal half-inch by adhesive strapping. This scalpel, however, is an unsatisfactory instrument as the wall of the abscess is often thick and indurated and a knife slit does not drain It is therefore necessary to remove the knife and open up the incision with sinus forceps. This takes time and is often difficult to accomplish. A much better tool is a sharp-pointed (stainless steel is best) bayonet-shaped sinus forceps (usually known as St. Clair Thomson's quinsy opener) with which the whole manoeuvre can be done in one stage. The pointing area may be obvious, but if there is doubt, the stab should be made well in at the midpoint of an imaginary line joining the last upper molar tooth (or where it should be) and the base of the uvula in its displaced position.

Procedure

Instruments

The patient should be seen daily for several days as the pus may not all escape at once and the wound may need to be kept open.

Retropharyngeal abscess

The same technique may be followed for a retropharyngeal abscess of pyogenic origin. In small children this may take the place of a quinsy. The moment it is opened the child's head should be tipped downwards and forwards into a bowl between the feet of the assistant, thus guarding the airway. Tuberculous abscesses should be opened externally from behind the sternomastoid muscle.

(e) *Prognosis*

In the vast majority of cases of acute tonsillitis even when complicated by quinsy, the outlook is good. Only in cases of septicaemia, septic thrombophlebitis and cellulitis of the neck is any danger to be envisaged, and with modern chemotherapy and antibiotics such conditions are increasingly rare.

(2) Chronic tonsillitis

Chronic tonsillitis does not lend itself to medical treatment. Local applications such as Mandl's paint or ferric perchloride or the silver colloids will clear up superficial infection but do not touch the deeper crypts or parenchyma. Systemic medication is of little avail, and cupping, cautery or scarification do not help and may make matters worse Persistent chronic infection can be satisfactorily dealt with only by complete removal of the tonsils and of any adenoids which may be present.

(3) After-treatment

Convalescence should be adequate and the return to work not hurried. Fresh air, and particularly a change at the seaside or other healthy locality, with good food and an iron tonic are usually all that is required.

9. REMOVAL OF TONSILS AND ADENOIDS

(1) Indications

Removal of the tonsils and adenoids is indicated by the following signs and symptoms.

(a) Recurrent attacks of acute inflammation especially when associated with quinsies. Tonsils are important in this case. *Inflammation*

(b) Gross obstruction to respiration, phonation or deglutition, and interference with the palatal, faucial, and pharyngeal musculature preventing a proper scavenging of the post-nasal space. Both tonsils and adenoids are important here. *Obstruction*

(c) Recurrent Eustachian catarrh and attacks of acute otitis media: adenoids are of great importance here. *Catarrh*

(d) Persistent cervical adenitis in glands associated with the tonsils, and tuberculous adenitis when there may be primary infection in the tonsil or secondary infection from the same source. *Adenitis*

(e) Focal sepsis, especially in nephritis, rheumatism, arthritis and thyrotoxicosis. *Sepsis*

(f) Diphtheria carriers.

(g) Malignant neoplasms

Disappointment may result if the operation is done merely for recurrent colds without any of the above indications being present. It should be remembered that this is often the first surgical procedure to which a child may be subjected and an unsuspected haemophilia may be encountered. *Haemophilia* Operation should always be deferred to an afebrile or quiescent period, also if any inflammation is present on admission. Elliott (1939) did pre-operative and post-operative blood cultures in 100 tonsillectomies and found a bacteraemia in the post-operative phase in nearly 40 per cent of the cases. At least 6 weeks should elapse after a quinsy before radical operation. Operation is probably better deferred during an epidemic of poliomyelitis *Poliomyelitis* In nephritis and thyrotoxicosis, undue bleeding may be encountered at operation.

(2) Methods

If removal is indicated this should be complete. The old operation of tonsillotomy—removal of the prominent part of the tonsil—left a scarred *Tonsillotomy* stump which often gave great trouble. In 1928, Rhoads and Dick of Chicago investigated the danger of tonsil stumps. In a double series of cases of tonsils removed for the first time and of removed stumps, they made bacterial counts, microscopic examinations, and tabulated the systemic reactions. In the first series, the bacterial count per gramme of removed tonsil averaged 5,693,000 as compared with 7,341,000 in the stumps, or remnants. In the latter, the outstanding microscopic change was fibrosis and in many cases the crypt orifices were closed and the crypts themselves dilated by exudate and organisms

Under the heading of imperfect operations must be included the use of *Imperfect operations* caustics such as London paste and diathermic coagulation. Both methods are nearly always incomplete and there is the added danger that in these imperfect operations the mucous membrane tends to grow in and cover the remnant so that it is no longer evident macroscopically except in attacks of

inflammation or to the experienced ...
that a high proportion o ...
incomplete operations, and relatively few to the well recognized tendency for the remaining islands of lymphoid tissue in Waldeyer's ring to increase after enucleation of the faucial tonsils and adenoids.

Teleradiation

Teleradiation has been advocated for the destruction of the tonsils. In adequate dosage there is some risk of destruction of the salivary glands with a resultant dry mouth. A scarred remnant is very likely to remain and this is a disadvantage. Radiation may have a place, however, in the occasional cases of recurrent lymphoid hypertrophy in the post-nasal space, when apparently perfect operations have failed to stop recurrent growth.

The fact remains that whenever the indication is clear, surgical removal is still the surest and most satisfactory procedure.

(3) Types of operation

There are two types of operation for the tonsil· (a) the guillotine; (b) dissection. The adenoids are removed by curette or adenotome.

(a) *Tonsils*

Instrument

(i) *The guillotine.*—This is still used by many surgeons in small children and when used with skill is admirable The simplest form of instrument is the best, and Heath's modification of Mackenzie's pattern made in stainless steel cannot be improved upon. The knife should be relatively blunt as it is desirable to dislocate and crush out the tonsil rather than to exert a cutting action. The operation should be done under general anaesthesia, and complete relaxation for an adequate time with a rapid return of the cough reflex is the aim. A careful examination for loose teeth should be made beforehand

Examination of teeth

Size of ring

A guillotine should be chosen the ring of which is slightly smaller than the tonsil to be enucleated, but not so small that bruising is caused by forcing the tonsil through the ring. By the use of an incisor bearing gag of the Doyen or similar pattern, both sides can be cleared without movement of the gag.

Position

The guillotine operation should be done with the child lying on his back and, if time permits, the adenoids are also well done in this position as the head can be firmly fixed and the curette kept more easily in the midline. Deviation to one or other side means risking damage to the Eustachian cushions. If, however, there is much blood in the throat after the tonsils have been enucleated, then the child should be turned on to his side with head low and the adenoids done in the lateral position.

The stages of operation can be followed clearly by reference to Figs. 116–121 and Figs. 127 and 128.

Fig. 116. The mouth is held open with a Doyen or similar pattern incisor-tooth gag which should be opened slowly and steadily and without twisting, to prevent dislocation of the teeth. The lower jaw should be held up digitally by pressure behind the angle or under the point of the chin and on no account by levering the lower grip of the gag forward against the lower incisor teeth. The ring of the guillotine is inserted between the tonsil and the posterior pillar of the fauces.

Fig. 117. The tonsil is lifted up under the anterior pillar and pressure with the index finger of the other hand threads the tonsil through the ring.

Fig. 118. When through, the blade is pressed home to trap the tonsil and a dimple shows on the anterior pillar. Both hands are used to crush the blade home around the tonsil.

Fig. 119. The guillotine is rotated away from the palate, thus stripping out the upper pole of the tonsil

Fig. 120 A rolling movement out of the mouth then strips away the lingual attachment.

Fig. 121. If very adherent, after crushing home, the blade can be held shut by one hand and the index finger of the free hand used to strip between the ring of the guillotine and the tonsil bed.

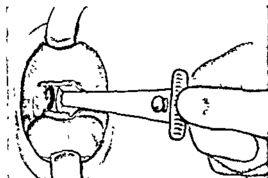


FIG. 116

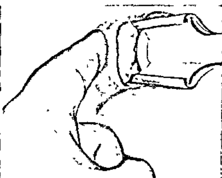


FIG 117

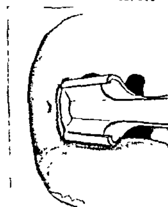


FIG 118

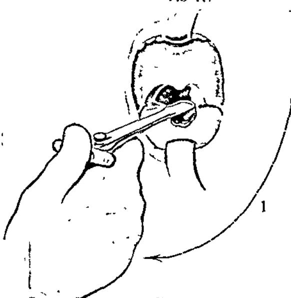


FIG 119

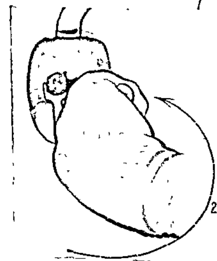
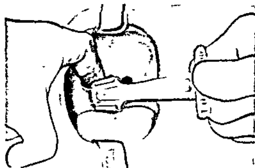


FIG 120



In all these manipulations the surgeon should preferably be ambidextrous, holding the guillotine in the right hand for the right tonsil and the left hand for the left tonsil. The patient should be lying on his back with the surgeon at his right side facing the head of the table.

Incomplete removal

If examination of the tonsillar fossa or of the removed tonsil shows that removal has been incomplete, then it is better to turn the child on to his side, continue the anaesthetic and dissect out the remnant, as only the most expert can remove this by a second application of the guillotine.

Local anaesthesia

(ii) *Dissection.*—Dissection is the method of choice for adults and larger children. Under special circumstances the operation can be done under local anaesthesia (1–2 per cent Novocain injected round the capsule of the tonsil through the anterior and posterior pillars) with the patient sitting up; but general anaesthesia is preferable and should be used unless contra-indicated by a condition such as phthisis. A transnasal endotracheal tube gives the greatest comfort and safety, as the larynx can be packed off.

Mill (1947) says: "The depth of anaesthesia is readily controllable and at the end of the operation, when the patient is allowed to become 'light', the bleeding points may be readily found and ligatured. Because of this, post-operative reactionary haemorrhage is much less common than was formerly the case, and the incidence of lung abscess and chest complications has been very much reduced."

In order to deal with the adenoids the tube can be drawn out through the mouth.

If endotracheal anaesthesia is not available, the anaesthetic can be administered through the anaesthetic tube incorporated in the spatula of the Boyle-Davis gag; this gives the best exposure for the operation but the larynx cannot then be packed off. Generally under local anaesthesia a gag is not used, but it may be necessary to depress the tongue with a Lack spatula to obtain a good view of the field of operation. The actual dissection is the same under local or general anaesthesia and will be described under the latter heading (*see* p. 295).

(*b*) *Adenoids*

The best type of adenoid curette is St. Clair Thomson's modification of the Gottstein pattern. This has a safety cage attached which collects the pad of adenoids and prevents it dropping into the pharynx with possible risk of inhalation. The blade of the curette should be as sharp as possible for only then is a clean removal possible without tearing the pharyngeal wall.

La Force adenotome

Some prefer a La Force pattern adenotome in which a flexible blade runs from behind forward in the grooved margins of a "box" and traps the adenoids. The disadvantage of this instrument is the difficulty of fitting it to different shapes of nasopharynx.

Adenoids can be removed with the patient lying on the back or, if no endotracheal tube is used and the bleeding is so free as to endanger the airway, in the lateral position. It is easier to control the direction and pressure of the curette or adenotome with the patient on the back.

If endotracheal anaesthesia is being used the endotracheal tube can be disconnected at the nostril, pushed into the nasal passage, withdrawn through the mouth and reconnected.

The technique of curettage is illustrated in Figs. 122–126.

Fig. 122. The index finger of the right hand palpates the nasopharynx, estimating the amount of adenoid vegetation and the approximate size of the nasopharynx. The vegetations are massaged into the midline and away from the lateral recesses and a curette or adenotome of suitable width is selected.

Figs 123 *and* 124. The curette is passed behind the soft palate and its anterior edge rests against the back of the septum The handle is gripped by the right hand as a dagger is gripped for "stabbing". The anaesthetist or an assistant steadies the head and closes the nostrils.

Figs. 125 *and* 126 The index finger of the other hand is used to steady the shaft at the point where the pin fixes the cage. This also marks the fulcrum point about which the curette should be rotated in its backward and downward stroke.

Fig. 127. The patient is turned on the side, or blood is sucked away. In the guillotine operation sponges in holders can be held in the tonsil fossae in the crossed position and the chin held forward by the index finger of the lower hand.

Fig. 128. *The tonsil removed showing capsule complete. If any cut or torn surface* shows on the capsule a remnant may have been left and should be looked for and removed if necessary by dissection.

After operation the patient is turned on the side with the head lowered over the edge of the table. If necessary the latter can be lowered at the head end.

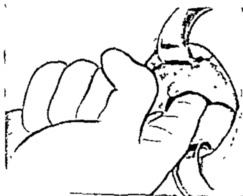


FIG 122

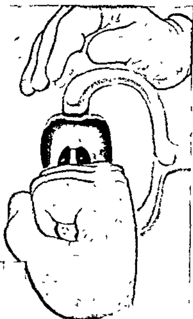


FIG 123

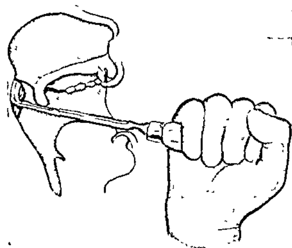


FIG 124

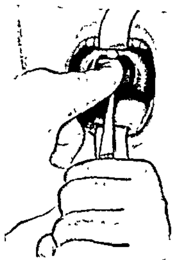


Fig. 125

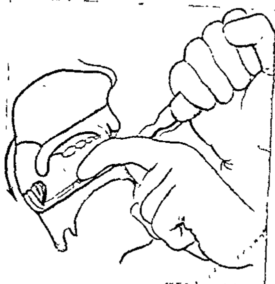


Fig. 126

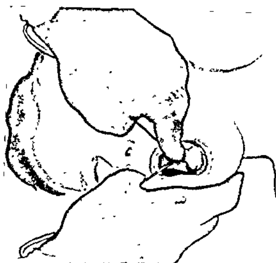


Fig 127

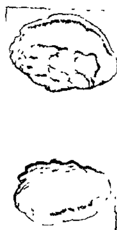


Fig 128



(a)



(b)



(c)

Fig. 129.—Mistakes to avoid: (a) The gag is too wide open, forcing the chin and tongue down on to the airway. (b) The adenoid curette is pulled straight down instead of rotated and the posterior pharyngeal wall may be split. (c) The adenoid curette is not in the midline and the Eustachian cushion may be damaged.

(4) Dissection under general anaesthesia

The most comfortable position is for the operator to work from the head *Position* of the table with the patient lying on his back with the head extended. Hyperextension is not necessary and is, in the author's opinion, contra-indicated as it causes congestion of the vessels of the neck and oedema of the tissues of the throat. Comfortable exposure and inspection can be obtained by sloping the table into the Trendelenburg position; the gag can be supported by a jack with security of fixation and the elimination of a rather tiring manual elevation by an assistant.

The steps of the enucleation are indicated in Figs. 130–136.

Fig. 130. Patient with head flat on table, Boyle-Davis gag and breast-plate jack in position. If a comfortable view is not then obtained from the head of the table, then the whole table can be tilted. This is better than extension of the head by a sand bag under the shoulders or dropping the head-piece, as this position causes congestion of the vessels of the neck and engorgement and oedema of the field of operation.

Fig. 131. Surgeon's view of the field of operation, with transnasal endotracheal anaesthetic tube Wet gauze strip can be packed around the tube to shut off the larynx below and the nasopharynx above

Fig 132. The right tonsil seized by a volsellum and drawn out of its bed towards the midline. A Freer's elevator breaks through the mucosa of the anterior pillar as near the tonsil as possible and opens the space filled with areolar tissue between the muscles of the pharynx and pillars of the fauces and the capsule of the tonsil. A suction tube is shown in position

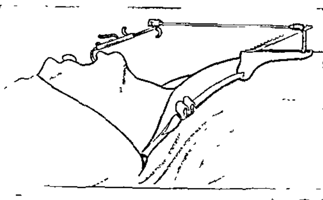


FIG 130

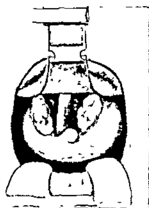


FIG 131

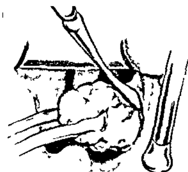


FIG. 132

Fig. 133. The anterior pillar has been defined and the elevator is being swept around the upper pole, dislocating it from its bed in the soft palate. The posterior pillar is then defined in a similar manner.

Fig. 134. The tonsil has been freed except at the lingual pole and a band of muscle fibres inserted in its deep surface divided. An Eve's tonsil snare has been passed over the remaining lingual attachment and cuts through it with a slow crushing movement.

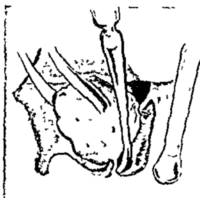


FIG 133

Fig. 135 The fossa is filled with gauze strip and left to allow retraction of vessels and the cessation of capillary oozing. If necessary, bleeding points are picked up by pressure forceps and tied with Coakley's double hitch slip knot

Fig. 136. If there is much general oozing, as *opposed to definite bleeding points, then the* fossa can be packed with gauze smeared with B.I P.P. and the pillars sutured together over this with any suitable suture-carrying needle on a handle. Fine toothed dissecting forceps, or a Gillies hook, can be used to withdraw the suture from the needle eye.

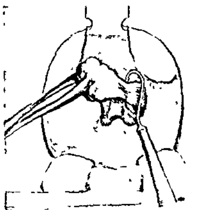


FIG. 134

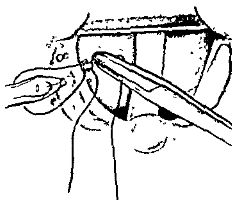


FIG 135

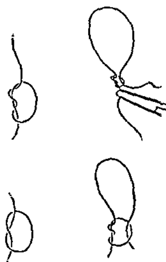


FIG. 135 *(cont.)*

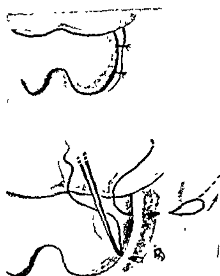


FIG 136

Gentle gauze packing and patience usually ensure haemostasis but occasionally a spurting artery or gushing vein may need picking up and ligating. Such vessels are usually found in the midline of the long axis of the fossa either at the palatal or lingual end, but quite frequently a troublesome vessel is found under the upper-third of the anterior pillar. Several devices have been invented for applying the ligature but the author favours the slip knot (Coakley) method shown in Fig. 135. Very occasionally, troublesome oozing from many points can only be controlled by packing the fossa and stitching the pillars over the pack. A smear of B.I.P.P. over the pack enables it to be left *in situ* for several days without getting foul. *Haemostasis*

When the operation is over the patient should be returned to bed in the lateral position without a pillow and kept in this position until fully recovered from the anaesthetic. In this way the airway is guarded and any bleeding is at once revealed

The immediate risks are an obstructed airway caused by a falling back of the tongue, a forgotten swab, or a blood clot, and haemorrhage which may be swallowed and concealed until it assumes a dangerous extent. A tongue clip should always be available to draw the tongue out, and any clot should be removed with sponge forceps. *Risks*

A tendency to ooze can sometimes be controlled by the administration of morphine but if it continues, direct pressure can be tried or it may be necessary to return the patient to the theatre. In this event it is unwise to waste time hunting for a specific bleeding point; it is quicker and more certain to pack and suture.

The sucking of ice is not recommended as it leads to swallowing and the bleeding may again be concealed.

After-treatment

To relieve pain, aspirin in mucilage is most efficacious and is more easily swallowed if the ears are held firmly as previously mentioned. Soft food can be given the same evening if the operation has been performed in the morning. This ensures a better night as pain and discomfort is not further aggravated by hunger. The sooner that a patient starts to swallow the quicker the healing and convalescence. Patients need not be rigidly confined to bed, as a rule they can get up for sanitary purposes the day after operation and are usually ready for a bath on the third or fourth day. *Pain* *Food*

After haemorrhage, the most troublesome complication is likely to be otitis media. Cervical adenitis, and sometimes a paralysis of the soft palate, may occur. Lung abscess, once so common in the United States of America, but now much less so, has always been rare in Great Britain. *Complications*

Scarring of the palate with distortion as a result of undue trauma at operation may be responsible for a troublesome post-nasal catarrh. *Catarrh*

The results of operation are excellent in properly selected cases with skilled operative and anaesthetic technique.

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[References to other titles are given under Tonsils in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 12, p 40.]

TROPICAL DISEASE—SURGERY IN

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1. INTRODUCTION

329.] Although there is no "tropical" surgery, *sensu stricto*, surgery in the tropics presents problems additional to those normally occurring in cosmopolitan practice. Patients will be seen with disease more advanced than is usual among sophisticated populations; concomitant infections often complicate surgical conditions; heat, moisture, dust, insects and primitive hygiene favour the dissemination of incidental infections; surgical conditions may be mimicked by infections amenable to medical treatment; native fears, superstitions and local customs may have to be considered; and adverse environmental factors throw a further strain on both patients and staff. Consequently not only high surgical skill but also some knowledge of tropical diseases, constant alertness to their possibility, the most meticulous attention to operative technique, and close post-operative supervision are demanded from the surgeon in the tropics.

2. EFFECTS OF HEAT

A high environmental temperature, humidity, fever, and illness with vomiting, diarrhoea, or ileus may all combine to precipitate or aggravate the pathological effects of heat. *Anaesthesia* Anaesthesia may disturb heat regulation; atropine may interfere with sweating; relaxation of peripheral vessels by anaesthesia or shock may bring about fluid loss; pre-operative or post-operative vomiting, diarrhoea, ileus or fever may deplete the body of fluid and sodium chloride. The pathological effects of heat may develop rapidly, and unless treated immediately may soon result in irreversible and fatal neural changes. Consequently the surgical staff should be constantly on the alert for the first signs of breakdown in a patient's temperature regulation; vigilance should be doubled as the wet-bulb air temperature approaches 28° C. (82° F.).

(1) Heat exhaustion

Types Heat exhaustion may be of two types. In the first, the patient is pale, collapsed, sweating profusely, and may have vomiting and cramps; the skin temperature is low but the rectal temperature may be raised, the blood-pressure and pulse-pressure are low, and syncope may occur on sitting or standing. Biochemical investigations show salt deficiency in both plasma and urine, haemoconcentration, and raised plasma protein and blood urea levels. *Fluid loss and salt loss* The condition is due to fluid loss and salt loss through the excessive sweating required to keep down the body temperature; other causes of fluid loss and salt loss may aggravate the condition.

The second type of heat exhaustion often arises when the peak of the hot

season is passed, and occurs in patients with dyshidrosis associated with some chronic skin condition, often prickly heat. *Prickly heat* There is reduced sweating, often with polyuria but rarely with vomiting, cramps or cardiovascular abnormality. Biochemical investigations may show some salt deficiency but not as marked as in the first type, and the patients are not dehydrated. *Defective sweating and skin changes* The condition is due to defective sweating associated with the changes in the skin, and consequently these patients respond poorly to treatment; the condition tends to recur, and as such persons are handicapped in the tropics they should, when possible, be permanently invalided to a temperate climate.

Treatment

The treatment of heat exhaustion includes cooling, preferably in an air-conditioned ward if possible, the liberal administration of fluid and, where indicated, of salt; if dehydration is severe or vomiting is troublesome, replacement intravenously may be necessary.

(2) Heat pyrexia

Heat pyrexia is a more serious condition of complete failure of heat regulation resulting from prolonged and excessive exposure to high temperature. Once the condition sets in it may develop rapidly and prove difficult to control.

Signs and symptoms Frequency of micturition and cessation of sweating usually precede the onset; it is a valuable routine when taking the temperatures of patients to observe whether sweating is normal by feeling in the axillae. In the early stages of heat pyrexia the patient is flushed, the skin dry and burning, the temperature high, the pulse full and quick, the blood-pressure elevated, and dehydration not usually prominent. As the condition progresses the pupils dilate, Cheyne-Stokes respiration sets in, *Cheyne-Stokes respiration* the pulse becomes irregular and weak, and the deep reflexes are lost, delirium, twitchings, convulsions and coma herald death, which may occur within a few hours of the onset of the condition Blood biochemical changes are slight. There is oliguria with albuminuria and occasionally slight reduction in urinary chlorides.

Treatment

Reduction of temperature At the first sign of heat pyrexia urgent measures to reduce the temperature, such as cold sponging under fans, are essential. Where there is venous congestion venesection has advocates, and drainage of cerebrospinal fluid may help if there are cerebral signs. In an emergency it may be difficult to exclude with certainty the possibility of cerebral malaria; if there is any doubt quinine dihydrochloride, 0 6 gramme (10 grains) should be given intravenously. *Relapses* After a favourable response to treatment relapses are not infrequent, the patient should therefore be very carefully watched and, if possible, nursed in an air-conditioned room.

(3) Salt and fluid loss

All surgical patients in the tropics, especially those suffering from fever, should have a liberal supply of water, and, if the body is depleted of salt, extra salt should be given. Examination of the urine for chloride is a practical clinical guide to salt depletion, but it should be noted that retention of salt in the body may be part of the normal reaction after injury or operation. If fluids cannot be taken by mouth, fluid loss may be made good with 0 18 per

Rectal drip

cent sodium chloride solution (1 part physiological saline with 4 parts tap-water) by rectal drip, or with 0·18 per cent sodium chloride in 4 per cent glucose solution (1 part physiological saline with 4 parts 5 per cent glucose solution) intravenously. Salt loss, due to sweating, vomiting, diarrhoea or ileus, may be countered by 0·9 per cent sodium chloride solution intravenously, but the blind infusion of saline solution without regard to the salt balance is of questionable value.

3. COMPLICATING FEVERS

Risk of post-operative infection

Boils and other pyodermic conditions are common in the tropics, and although in themselves of minor surgical importance, they indicate the need for meticulous pre-operative preparation of the skin. Extra care may also be required to prevent post-operative infection of wounds, the risk of which is increased by humidity, dust, insects, poor hygiene and the difficulties of controlling primitive patients. It is a fallacy, however, that first-class surgery cannot be carried out in the tropics.

(1) Malaria

Presence of parasites

Blood slides

In the tropics, post-operative fever without definite focal signs may well be due to some general infection, accompanying or activated by the illness or the operation, rather than to local sepsis. Among such infections malaria ranks high. Patients who are suffering from malaria practically always show parasites in the blood, if this be competently examined, but on the other hand a few parasites in the blood, particularly of a native, are not necessarily a complete and sufficient explanation of severe fever. However, where there is any doubt about the diagnosis, it is always safer and usually beneficial to give antimalarial treatment. If, in an emergency, antimalarial treatment is given on clinical grounds only, blood slides, for subsequent examination, should be taken before the treatment is started.

Treatment

For malaria of average severity proguanil, 0·1 gramme, mepacrine hydrochloride, 0·1 gramme, or quinine, 0·6 gramme, may be given 3 times a day by mouth, the first two drugs may take a little time to act, and initial "loading" doses of 2 or 3 times the amount stated may be given on the first day of treatment in order rapidly to build up therapeutic concentrations in the blood. In severe cases where rapidity of action is essential, initial doses should be given parenterally; proguanil and quinine may be given intravenously but mepacrine hydrochloride should be given intramuscularly. Parenteral injection may also be required for patients who cannot swallow or who are vomiting.

"Blanket" treatment

For patients from heavily infected areas it may be considered desirable to give a fortnight's "blanket" course of antimalarial therapy to cover operative procedures; many patients in such areas will already be on routine malaria "suppressive" treatment, in which case the suppressive régime should be continued. Similar precautions may be taken with recipients of blood transfusions in malarious areas where there is a risk of passive transmission of malarial infections.

The surgeon in the tropics may also be involved with malaria in other ways. The chronically enlarged spleen of malaria may be ruptured and demand surgical intervention. *Ruptured spleen* Intramuscular injections of antimalarial drugs may sometimes result in local abscesses which may become infected and require drainage. *Local abscesses* Injections of such drugs in the neighbourhood of large nerve trunks may produce palsies, so that splinting and physiotherapy may be required during the period of recovery. *Palsies*

(2) Blackwater fever

Occasionally during the treatment of a patient who has had much falciparum (malignant tertian) malaria, blackwater fever supervenes. This is an acute intravascular haemolysis, the exact aetiology of which is obscure, but it is possible that prolonged infection, even subclinical, in some way brings about a condition of sensitization so that treatment of a later attack leads not only to the destruction of the parasitized cells but to a large-scale haemolysis; it mostly occurs when quinine has been used.

Fever, loin pains, vomiting, rapid and severe anaemia, with the appearance of haemoglobin in the urine, and jaundice occur. Later oliguria and even anuria may follow; the urinary suppression was thought to be due to blocking of the renal tubules by the precipitation of acid haematin, but it is now suggested that it may be due to renal cortical ischaemia following shunting of the renal blood supply, such as seems to occur in the crush syndrome and in shock. *Oliguria and anuria*

Haemoglobinuria, fever and jaundice in a patient known to have had malaria is diagnostic of blackwater fever, although malarial parasites may not be found in the blood after the haemolysis has occurred; haematuria is readily distinguished by examination of the urine. In view of the modern theory of the anuria in blackwater fever, the surgeon may be called upon to perform splanchnic block; he may also be required to supervise blood transfusion in severe haemolysis.

(3) Fever due to urinary infections

Post-operative fever in the tropics may also be due to urinary infections, possibly because of the high frequency of intestinal infection and damage to the intestinal mucosa, sometimes with malnutrition, and with dehydration reacting adversely on the kidney and urinary tract. Examination of the urine makes the diagnosis clear.

4. ABDOMINAL CONDITIONS

(1) Amoebiasis

(a) *Amoebiasis simulating other conditions*

Amoebiasis has been considered elsewhere (Vol. 1, pp. 162, 166 and 172) but it may be emphasized here that this disease can simulate almost all other subacute or chronic abdominal conditions. Particularly may it imitate appendicitis; nevertheless clear evidence of acute appendicitis, such as fever and definite focal signs with a high or rising neutrophil leucocytosis, will call for laparotomy, but if an amoebic infection is also found, the operation should be followed by intramuscular injections of emetine hyd... *Appendicitis*

0·06 gramme (1 grain) daily for 10 days, as otherwise healing may be delayed and the wound and skin may become infected with amoebae.

(b) Other conditions simulating amoebiasis

Carcinoma of the colon

On the other hand, various abdominal conditions may be mistaken for amoebiasis. What is perhaps particularly serious, is that carcinoma of the colon may be diagnosed as dysentery; the sinister significance of dysenteric symptoms may be overlooked, or a malignant mass or ulcer may be accepted as an amoeboma. Complete clinical consideration, laboratory and biopsy examination, and response to emetine treatment usually obviate mistakes, but difficulty may arise from the coexistence of an amoebic infection with a neoplasm. If operation on the bowel is indicated, any amoebic infection should first be controlled by a preliminary course of emetine therapy, as otherwise healing may be unsatisfactory. For the same reason the surgical treatment of piles, a common sequel to dysentery, should not be undertaken in the presence of amoebic infection.

Piles

(c) Diagnosis and treatment of intestinal amoebiasis

Stools
Sigmoidoscopy

The key to the diagnosis of intestinal amoebiasis is competent examination of the stools, repeated 5 or 6 times if necessary; sigmoidoscopy is of secondary importance, its chief value being to reveal perhaps a carcinoma or confirm a diagnosis of ulcerative colitis. Intestinal amoebiasis usually responds readily to emetine preparations, such as emetine bismuth iodide, 0·18 gramme (3 grains) by mouth nightly for 12 days; each dose should be preceded by a sedative, such as phenobarbitone, 0·06 gramme (1 grain) to minimize vomiting. This course may be followed by an iodohydroxyquinoline preparation, for example Dihaloquin, 0·6 gramme (10 grains), thrice daily for 3 weeks, and then an organic arsenical drug, such as carbarsone, 0·25 gramme (4 grains), twice daily by mouth for a further 2 weeks.

Hepatic amoebiasis.—Diagnostic confusion may arise from amoebic infection of the liver, which is characterized by fever, pain in the region of the liver, and sometimes of the shoulder, tenderness and enlargement of the liver, neutrophil leucocytosis, and elevation and immobility of the diaphragm; evidence of amoebic infection of the bowel may or may not be present. Consequently symptoms and signs suggesting disease of the liver, gall-bladder, or base of the lung in patients in the tropics should always raise the question of possible hepatic amoebiasis. The infection usually responds well to treatment with emetine hydrochloride, 0·06 gramme (1 grain) being given daily intramuscularly for 10 days.

Abscess

Aspiration may also be required with a large abscess, but open drainage should be avoided as it is unnecessary and is usually followed by secondary infection, delayed healing, or by more serious complication. It may be noted that the amoebae, because of their location in the wall of the abscess, may not be found in the aspirated pus. It is of interest that chloroquine, an 8-aminoquinoline compound, developed for the treatment of malaria, is useful for the treatment of hepatic amoebiasis, especially in the rare case refractory to emetine, because although the drug is relatively only feebly amoebicidal and is therefore practically valueless in intestinal amoebiasis, it becomes concentrated in the liver some 400–600 times from the blood plasma; it may

Chloroquine

be given by mouth in doses of 0·25 gramme (4 grains) 3 times daily for 2 weeks unless toxic signs such as nausea, pruritus or visual defects supervene.

(2) Hydatid disease

Enlargement of the liver may be due to hydatid disease, the diagnosis of which may be aided by eosinophilia and by demonstration of a positive intradermal (Casoni) test and complement fixation test with active hydatid antigen. (*See* Hydatid Disease, Vol. 5, p. 46.) *Casoni test*

(3) Schistosomal infection

Liver disease, sometimes with fever, enlargement, pain and tenderness in the region of the organ, and a high eosinophil leucocytosis may also be due to schistosomal infection, but the surgeon is more likely to encounter this infection when it causes haematuria or dysenteric symptoms, or when later neoplastic changes supervene in the infected tissues. (*See* Schistosomiasis, Vol. 7, p. 473.)

(*a*) *Diagnosis*

The presumptive diagnosis may be assisted by schistosomal intradermal and complement fixation tests, but the definitive diagnosis is made by finding the specific eggs in the urine or stool, or in biopsy material from the bowel or more rarely from the liver. In intestinal schistosomiasis eggs may be scanty in the faeces because *Schistosoma mansoni*, the common intestinal schistosome, lays only a few eggs at a time; in such cases sigmoidoscopy may be a useful procedure not only in revealing ulcers and inflammatory papillomas, but in obtaining punch biopsy material in which eggs may be found when examination of the faeces has failed to reveal them. *Sigmoidoscopy*

(*b*) *Treatment*

The treatment of schistosomal infections is by the parenteral injection of trivalent antimonial drugs, or, less efficiently, of emetine. Recently miracil-D, a new thioxanthone compound, has been introduced and shows great promise; it is given by mouth in doses of 5–10 milligrams per kilogram of body-weight 12-hourly for 10 doses. Reparative surgery or excision of local malignant changes may be required in late schistosomiasis.

(4) Helminthic infestation

Chronic abdominal symptoms, sometimes suggesting peptic ulceration, may be due to hookworm infestations or other intestinal helminths. Careful consideration of the history will usually reveal some atypical features. There is usually an eosinophilia, and examination of the stools will reveal the presence of characteristic ova; these can often more easily be found after concentration by mixing the stool with 33 per cent zinc sulphate solution, centrifuging and examining both the deposit and also the top layer of the supernatant fluid in order to detect the various eggs, both of high and low specific gravities. *Hookworm*

(5) Ascaris infestation

Ascaris worms, owing to their large size and migration, may give rise to various surgical emergencies; they may enter the appendix or the bile duct;

large numbers may become impacted, thus obstructing the gut; they may perforate the gut; or they may migrate up the oesophagus, over the epiglottis, and to the larynx, producing spasm. While certain emergencies will obviously require operative procedures, less acute abdominal symptoms in tropical practice should always lead to examination of the stool for ova.

(6) Treatment of intestinal nematode infestations

Saline purge

The majority of the pathogenic intestinal nematodes are expelled by tetrachlorethylene, 4 *cubic centimetres, to which may be added oil of* chenopodium, *1 cubic centimetre*, followed after 2 hours by a saline purge. The anthelminthic drugs are given in the morning after 2 days' preparation on light diet and saline purgation; alcohol and absorbable fats should be avoided while the drugs are being given, lest consequent increased absorption of the drugs leads to toxicity to the patient.

(7) Differential diagnosis of sprue

Gastro-jejuno-colic fistula

Regional ileitis

When faced with flatulent dyspepsia, wasting, anaemia, deficiency signs, diarrhoea and evidence of poor absorption of fat and glucose, the surgeon *may be faced with the differentiation of sprue from certain surgical con*ditions. Of these, gastro-jejuno-colic fistula is important; a history of peptic ulceration, especially if treated by operation, a sudden onset of symptoms, and x-ray examination by barium enema or barium meal, are helpful in arriving at the diagnosis. X-ray examination, a palpable tumour, and less marked deficiency signs, are useful in differentiating regional *ileitis from* sprue.

(8) Abdominal perforation in typhoid fever

The surgeon may also be required to deal with urgent abdominal complications of certain general infections, as for example, perforation in typhoid fever, although this complication is likely to become rarer since early treatment of typhoid fever with chloromycetin (0 25 *gramme by mouth* 2-hourly until the temperature is normal, then 4-hourly for a few days) *rapidly controls the disease*, and seems likely to rob it in the future of all its dangers.

5. OTHER CONDITIONS

(1) Lymphogranuloma inguinale

Subacute inguinal adenitis

Inguinal swellings are common causes of patients seeking surgical advice. Apart from straightforward surgical conditions such as hernias, glandular swellings may suggest a need for operative intervention. Among the latter, [illegible] …senting in the [illegible] to rest, but [illegible] resolution is greatly accelerated by treat[illegible] aureomycin (0·25 gramme by mouth 4-hourly), and this antibiotic [illegible] …ly displace the sulphonamide or [illegible] …gs or protein [illegible] previously used. Sometimes the [illegible] tempted to [illegible] …ds, but this is usually

unnecessary and may lead to lymphatic obstruction; simple incision of the gland should always be avoided, however, as this results in the formation of chronic sinuses and very prolonged delay in healing. *Lymphatic obstruction*

Diagnosis of the infection may be assisted by the Frei intradermal reaction, a nodule being produced in the skin of infected patients after intradermal injection of lymphogranuloma antigen. A complement fixation test may also be used; because of a common antigenic component, cross-reactions may be obtained with psittacosis. In the female or in the subjects of sodomy lymphogranuloma inguinale may result in rectal strictures. These strictures are of rubbery consistency, usually extending for a few centimetres within the anus, and are covered with a whitish finely mamillated mucosa, due to oedema from submucosal lymphatic blockage; sometimes ulceration of the mucosa occurs. Above the stricture the mucous membrane appears normal. The condition should be differentiated from a malignant stricture, as operation is unnecessary, and will only lead to further trouble from the presence of active infection and deeper lymphatic disease. (*See* Lymphogranuloma Inguinale, Vol. 5, p. 487.) *Frei reaction* *Rectal stricture*

(2) Filariasis

(*a*) *Wuchereria bancrofti infections*

In filariasis, particularly associated with *Wuchereria bancrofti* infections, surgery may occasionally be required for abscesses, and for the treatment of elephantiasis, especially of the scrotum, surgical treatment of elephantiasis of the extremities is less often satisfactory, and such conditions are best treated by periods of elevation of the affected part and the wearing of elastic stockings, together with specific chemotherapy (*See* Elephantiasis, Vol. 3, p. 362.) *Elephantiasis*

(*b*) *Loa loa infections*

In filariasis due to *Loa loa* infection, excision of adult worms appearing under the conjunctivae or mucous membranes may be undertaken through a tiny incision under local anaesthesia, but as the infections are nearly always multiple the procedure is of little real value; during extraction care should be taken not to damage the worm, as otherwise severe local allergic reactions may result.

(*c*) *Onchocerca volvulus infections*

Another important filaria, *Onchocerca volvulus*, occurring particularly in tropical Africa, Central America and Mexico, frequently produces tumours in the subcutaneous tissues from which embryos migrate through the skin. The importance of the disease rests in the fact that should the embryos reach the eye, choroido-retinitis, iritis or keratitis may result and blindness frequently ensues; in some areas 50 per cent or more of the population may suffer and a high proportion be blind from this "blinding filaria". Blindness appears commoner in adults whose nodules are situated in the scalp, face or neck, although in many patients nodules are extremely small or absent. *Blindness*

Diagnosis is made from the symptoms and signs of the disease, by finding embryos in shavings of the skin, or by puncture of a nodule. Excision and examination of the nodule will also reveal adult worms. Embryos may sometimes be seen in the eye by means of slit-lamp microscopy. Intradermal and complement fixation tests are also of value. *Diagnosis*

Excision of nodules

When nodules are present, particularly around the head, they may be excised surgically in order to remove the continued source of the embryos, but often infection is widespread, and probably in the future surgery will give place to chemotherapeutic treatment.

(*d*) *Treatment of filariasis*

Allergic exacerbations

In the past pentavalent antimonial compounds have been used with doubtful success for filariasis. Recently a piperazine derivative, (Hetrazan or Banocide) has been introduced, and it shows great promise; it is given by mouth in doses of 2 milligrams per kilogram of body-weight, 3 times daily for 3 weeks. During the first few days of treatment there may be allergic exacerbations probably associated with the killing of the parasites; these reactions may be severe in onchocerca infections, and consequently in this infection it is wise to start with smaller doses.

(3) Guinea-worm infections

Septic complications

Secondary infection

Surgical treatment may be required for guinea-worm infections. The adult female of this large filarial worm measures up to 100 centimetres in length by about 1–2 millimetres in diameter, and develops in the subcutaneous tissues; it finally produces a blister and later an ulcer, through which on contact with water the discharge of larvae occurs. Occasionally premature ejaculation of embryos may produce subacute sterile abscesses, and septic complications of the ulcer are frequent The ulcer should be protected by aseptic dressings, and the worm induced to empty its uterus by repeated stimulation with sterile water, because when the uterus is empty the worm ceases to retain its hold of the tissues and extraction is much easier. It may be extracted by gentle intermittent traction, the traditional method of winding on a small stick still having advocates, or it may be extracted through multiple incisions under local anaesthesia. In order to avoid anaphylactoid symptoms, care should be taken not to rupture the worm. Abscesses and secondary infection may require treatment by routine surgical, chemotherapeutic or antibiotic measures.

(4) Mycetoma

Surgery may be required for mycetoma, a chronic granulomatous condition, usually of the foot, due to infection by species of actinomyces, nocardia or monosporium. After an initial nodular lesion the overlying skin breaks down and chronic sinuses develop; in some cases the condition appears as a subcutaneous lesion which opens externally. Later there is destruction of soft and bony tissue, so that the foot becomes enlarged and distorted, although it is usually free from pain and haemorrhage. The sinuses exude semi-purulent fluid in which the fungus may be found. The glands and viscera are not affected and the general health usually remains good.

Treatment

Amputation

There is no tendency to natural cure. In the early stages excision or curettage followed by x-ray irradiation may be undertaken, but in the later stages amputation is necessary. Iodides are usually given in large doses, and large doses of sulphonamide preparations and antibiotics may be tried.

(8) **Poisonous bites** (*See* Bites and Stings, Vol. 2, p. 97.)

Since absorption of toxins of poisonous snakes or insects is extremely rapid, the surgeon is usually only concerned in treating the late septic complications of such poisonous bites. It may be of some surgical interest, however, to note that the toxin of the black widow spiders produces severe muscular cramps, rigidity and pain, especially marked in the muscles of the abdominal wall. This may simulate an intra-abdominal surgical emergency, and exploratory laparotomies have mistakenly been undertaken; some atypical features, cramps in other muscles, a search for the bite which may show only trivial marks and swelling and is usually about the genitalia since the spiders often rest in privies, the history of the case, and sometimes a rash, should prevent mistakes.

Black widow spiders

6. CONCLUSION

In climates where conditions favour general and superficial infections, for the majority of which there are now efficient chemotherapeutic remedies, the surgeon continually will be faced with fascinating problems taxing clinical acumen and diagnostic skill, and it will often be unwise to accept an apparently simple surgical picture at its face value. A careful and complete consideration of the case, aided by suitable laboratory investigations, will frequently provide a key to fundamental treatment, complementary to surgery and adding to the satisfaction of both surgeon and patient.

[References to other titles are given under Tropical Disease—Surgery In, in the Index Volume. The subject is also dealt with in the *British Encylopaedia of Medical Practice* (1939), Vol. 12, p. 247.]

TUBERCULOSIS

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1. DEFINITION

330.] Tuberculosis is the name given to an infection with the *Mycobacterium tuberculosis* which gives rise to demonstrable signs and clinical symptoms. Tuberculosis differs from almost all other infections in that a great majority

of all urban dwellers and a high proportion of rural dwellers in so-called civilized countries are infected at some time in their lives with the *Myco. tuberculosis*, yet only the minority of those infected develop tuberculosis.

2. HISTORY

Tuberculosis is a disease of great antiquity. It certainly existed many centuries before Christ. Hippocrates described pulmonary tuberculosis, and spinal caries has been found in Egyptian mummies.

3. BACTERIOLOGY

(1) Types

There are 5 types of *Myco. tuberculosis*—human, bovine, murine, avian and cold-blooded. These types can be distinguished by cultural methods and by their varied pathogenicity for animals. They are essentially pathogenic for their natural host. There is no evidence that they multiply outside the animal body, although under certain conditions they can remain alive for considerable periods.

Human type The human type is naturally a pathogen of man, but can be transmitted to *Bovine* some other animal species. The bovine type is a pathogen of cattle, but it is responsible for a considerable proportion of the cases of tuberculosis in man. *Avian* The avian type is a pathogen of birds; it also infects pigs, occasionally cattle and, very rarely, man. Feldman (1938), in an extensive and comprehensive review, considers that only 13 of all the recorded cases in man can be *Murine* ascribed to the avian type with reasonable certainty. The murine type is a *Cold-blooded* natural pathogen for voles and some other species of mice; the cold-blooded type infects reptiles and fish. Neither of the two last-mentioned types is known to infect man.

Frequency of human and bovine types The relative frequency of the human and bovine types of tubercle bacillus in human tuberculosis varies greatly from place to place and from country to country. The incidence of bovine tuberculosis in man has been extensively studied in Great Britain by Griffith (1930 and 1941), Blacklock (1947), Munro and Scott (1936) and others. They conclude that bovine tuberculosis is chiefly a disease of childhood and that it affects mainly the lymphatic glands of the intestinal tract. It is commonest in children under 5 years of age, but is not inconsiderable in adolescents and adults. Infection with the bovine type of tubercle bacillus is by no means confined to the intestinal tract lymph glands. The bovine type is the causative agent in about 25 per cent of cases of tuberculous meningitis and in an appreciable percentage of cases of pulmonary tuberculosis. The incidence of tuberculosis due to the bovine type of bacillus is higher in Great Britain than in Europe and much higher than in the United States of America, where eradication of most of the tuberculosis in cattle has resulted in the virtual eradication of bovine tuberculosis in man.

(2) Stability of type

There is no evidence of change of type of tubercle bacillus, either in the animal body or in artificial culture.

(3) Virulence

There is an extensive literature on the natural variations of the tubercle bacillus. It is not an easy matter to determine minor variations in virulence. Many of the reports of lowered virulence of certain strains of tubercle bacilli are based on insufficient experimental evidence. It is not generally realized how wide a variation in the extent of the disease process can follow the injection of equal doses of the same suspension of tubercle bacilli in susceptible animals. It is, however, clear from the literature that strains of lowered virulence for experimental animals are frequently found in certain forms of tuberculosis. Griffith (1941), in his review on virulence, mentions the frequency with which strains of lowered virulence occur in skin tuberculosis.

Diminution of virulence is often seen in strains of all the types of tubercle bacilli in artificial culture The extent to which this diminished virulence will occur in any given strain is quite unpredictable. The strain of tubercle bacillus known as B C.G., which is quite non-pathogenic to man or to *B C.G* susceptible animals, was originally a fully virulent bovine type. After years of culture on a series of glycerin potato slopes impregnated with bile, all virulence was lost. (*See* p 327.)

The relative virulence of the human and bovine types for man was for many *Relative* years confused by Koch's statement that the bovine type was not virulent *virulence* for man This statement was founded on the fact that tuberculosis due to the bovine type was at that time exceedingly rare in Germany. It has, however, been amply proven that the bovine type is certainly as virulent as the human type in man; some workers insist that the bovine type is more lethal to man than is the human type.

4. EPIDEMIOLOGY

Tuberculosis is an infectious disease. This has been postulated for many centuries, as the writings of the ancient Greeks testify, but it was not until 1868 that Villemin proved it by experiment It is a world-wide disease, clearly associated with civilization and particularly with urbanization. It is uncommon in mountainous areas, but common in large towns, particularly when overcrowding occurs. At one time tuberculosis was unknown in native races living under conditions to which Western civilization had not penetrated.

(1) Mortality

In Great Britain, the mortality from tuberculosis has decreased in the past 100 years so that it is now about one-sixth of what it was. The general trend *General* has been steadily downwards except for the years of the two World Wars, *decrease* when a rise in mortality occurred It is difficult to assess with any accuracy the cause of the decline, but it seems probable that it can be ascribed more to social improvements than to biological factors. Better nutrition and housing seem to be of more importance than heredity or acquired specific resistance.

A similar fall in the mortality figures from tuberculosis has been recorded from all the countries of Western civilization The fall in the United States of America shows a mortality figure in 1940 of only one-quarter of what it

was 40 years earlier. Rich (1946) states that there is no evidence for a decrease in the virulence of the tubercle bacillus or for an increased racial resistance. He quotes the increase in mortality in the blockaded countries during the two World Wars, an increase which ceased when the nutritional problem became easier. The main, but not sole, factor causing the decrease, Rich states, is the economic status. He reviews the process of industrialization of the countries of the world and points out how early in industrialization the mortality from tuberculosis rises markedly, but that as economic status improves, as a result of industrialization, the mortality figures fall. Whitney (1934) determined the death rates in occupied males in 10 states of the United States of America and found the highest rate in the unskilled workers and the lowest rate in professional men. The difference is almost certainly not one of occupational risk, but of economic status.

Economic factor

It is interesting to note that mortality in some South American countries, where industrialization is beginning, is on the increase. Particularly striking is the experience in South Africa. The mortality from tuberculosis in the native races rose to a phenomenal degree when they entered industrial life under miserable social and economic conditions. Where these conditions are still bad the mortality remains now very high, but where conditions have been markedly improved the mortality figures show a spectacular drop. Dormer, Friedlander and Wiles (1943), in their studies of tuberculosis in the native, have shown that the mortality in the native reserves, where the inhabitants live their natural life, is startlingly lower than it is under urban conditions.

Effects of occupation

The effect of occupation on mortality from tuberculosis has long been noted. There is an increased risk among miners and other workers exposed to dust containing metal or stone, particularly dust containing silica.

Age-group incidence

The mortality in different age-groups shows important variations. In Great Britain, 50 years ago, the highest point in the mortality curve was in early infancy, with another high point between the ages of 15 and 30 in females and from 40 to 50 in males. Now the highest point is in young adults. There has been a very striking fall in the death rate in infancy, in which nearly half of the deaths are due to tuberculous meningitis. The deaths among young adults are mainly due to pulmonary tuberculosis. The highest point in the female death rate is in the 20–25 age-group, but in the male it is in the 45–55 age-group. The change in the age and sex age-groups of the tuberculosis mortality curve since 1900 has been seen in the United States of America and in many European countries.

(a) *Racial differences*

It is generally believed that certain races are more susceptible to tuberculous infection than others. This would certainly appear to be the case from a study of the mortality rates among various races. For example, the mortality among the Negroes in North America is higher than among the white peoples. Cummins (1908) studied the incidence of tuberculosis among various races under military conditions and showed that very wide variations occur when comparing white and coloured races under similar conditions of service. Borrel (1920) compared the tuberculosis mortality rate in Senegalese soldiers in France during World War I with that in the Metropolitan French soldiers. He found that not only was the morbidity rate much higher in the

Senegalese, but that the mortality rate was almost equal to the morbidity rate.

It would, however, be wholly unjustifiable to conclude that the observed differences in racial mortality rates can be ascribed solely to a lower genetic resistance of the coloured compared with the white races. The influence of social and economic conditions has already been mentioned and is clearly of profound importance. Yet it does appear that there are racial differences. Primitive peoples, living in isolation under their native conditions, show a low incidence of tuberculosis, but when civilization reaches them, bringing with it a greatly increased infection risk, a large rise in the mortality rate has been observed. This is not always the case, as Dormer, Friedlander and Wiles (1943) point out in reference to the Zulu tribe. In several surveys in Zululand they found a high infection rate, judged by tuberculin testing, but a low morbidity and mortality rate. On the other hand, the mortality rate in the North American Indians increased very greatly as civilization spread West and permeated tribe after tribe. Perhaps the most convincing evidence for racial differences is seen in the difference between the mortality rates in Scandinavia and Great Britain. It seems unlikely that economic conditions vary sufficiently in these two groups of countries to account for the higher mortality rate in Scandinavia compared with Great Britain.

Primitive races

Zulus

It has been maintained that the Jews show a consistently lower mortality rate than the rest of the community, although the infection rate is not smaller. However, Rosenfeld (1907) showed that the difference between Jews and the rest of the community in Vienna was not greater than the difference between Protestants and Catholics. The whole question is very confused and it is not possible in the present state of our knowledge to postulate that race is a major factor in mortality.

(*b*) *Heredity*

In the Middle Ages heredity was looked upon as the vital factor in resistance to, or the development of, tuberculosis. Only by very few writers was tuberculosis considered to be an infectious disease. After Koch had shown that the tubercle bacillus was the causative agent of tuberculosis, opinion swung to the other extreme and heredity was counted as a factor of no importance.

Animal experimentation suggests that heredity can play an important part in experimental tuberculosis. Wright and Lewis (1921) showed marked and consistent differences in resistance to tuberculosis in a number of in-bred families of guinea-pigs. Lurie (1941) found a wide difference in the response of 6 in-bred families of rabbits to infection with bovine tubercle bacilli. Carmichael (1937) showed a very marked difference between the two races of cattle in East Africa under approximately equal conditions of exposure to infection and comparable environment.

Experiments on animals

It is obviously a very much more difficult matter to determine the influence of heredity on tuberculosis in man. It is impossible to standardize the exposure risks or environmental factors, nor can breeding experiments be undertaken Investigations into the influence of heredity have chiefly been on the incidence of disease in twins, identical and non-identical. Probably the extent of the investigations is insufficient to provide statistical proof either way. It does appear, however, that the chance of an identical twin developing tuberculosis when the other twin develops the disease is markedly higher than is

Incidence in twins

the case with non-identical twins. That tuberculosis develops more frequently in children of parents one or both of whom is tuberculous is, of course, no proof of the effect of heredity. The exposure to risk is obviously a greater continuing one than when neither parent is tuberculous. Statistics show that about two-thirds of the cases of tuberculosis arise in persons without tuberculous parents, but this is not adequate proof that heredity does not play a part.

Need for accurate information

Like so many of the problems in tuberculosis, our knowledge of the influence of heredity is woefully small; it is impossible to assess because of ignorance of the facts. Is it possible to get sufficient information to enable an accurate assessment to be made? Rich (1946) suggests that the question of heredity could be answered if reliable information were available from the examination and follow-up of the individual members of large groups of families carried out over an extended period of time; from the segregation of the children of tuberculous parents so as to compare the incidence of tuberculosis in these children with the incidence in those children of non-tuberculous parents, both groups being brought up in non-tuberculous surroundings; from the exposure of children of non-tuberculous parents to the same risk as children of tuberculous parents by placing them in tuberculous surroundings. These would be interesting experiments but, perhaps, socially undesirable.

(2) Morbidity

Social stigma

Our knowledge of the morbidity rate of tuberculosis in the world is surprisingly small. Considering that the disease has been recognized for many centuries and that it is a notifiable disease in certain countries, it might be reasonable to assume that accurate statistical information about its incidence would be forthcoming. There is a social stigma attaching to tuberculosis which deters many notifications, thereby falsifying the morbidity statistics to an unknown degree in those countries in which notification is statutory. In many countries where only the mortality is notifiable there is also a certain reticence about the notification of tuberculosis as the cause of death, and, finally, there are still many countries or parts of countries in which even registration of death is not statutory.

Many surveys have been made in the past to try to determine the infection rate with the tubercle bacillus by means of the tuberculin test, but the infection rate cannot be considered in any way as synonymous with the morbidity rate. It is wholly unwarrantable to label a person as tuberculous when the sole evidence for so doing is a positive tuberculin test without a history of symptoms and without demonstrable disease. Other surveys have been made using x-ray examination of the chest as the index of past or present pulmonary tuberculosis. Lastly, there is the evidence from post-mortem examinations in which careful search has been made for signs of past or present disease.

(a) *Morbidity judged by the tuberculin test*

There are unfortunately many technical varieties of the tuberculin test. The main ones in use today are the von Pirquet and the Mantoux tests. For the von

Pirquet test a drop of Koch's old tuberculin, undiluted, is placed on the forearm and a scratch is made through the drop by means of a lancet or needle; von Pirquet's test is largely outdated, but it is still used by some workers in Scandinavia. The Mantoux test consists of an intradermal injection of graded doses of either old tuberculin or purified protein derivative into the skin of the forearm. There is not, unfortunately, any standardization of dosage in the Mantoux test in the reported surveys. Some workers start with 0·1 millilitre of a 1:10,000 dilution of old tuberculin, proceeding if the test is negative to the same quantity of a 1:1,000 dilution and finally a 1·100 dilution before assessing any individual as positive or negative. Other workers have used only one dilution of old tuberculin, usually 1:1,000. Others again have used purified protein derivative, which has not always been standardized. Another method often used is tuberculin jelly or the tuberculin patch test. It can readily be seen that any strict comparison between various surveys is impossible.

Von Pirquet test

Mantoux test

Patch test

The percentage of persons positive to the tuberculin test—that is, the percentage of persons infected with the tubercle bacillus—appears to have decreased in each age-group as the mortality from tuberculosis has fallen. Early in this century, von Pirquet (1909) tested over 1,000 clinically non-tuberculous children in Vienna and found that 70 per cent were positive at the age of 10 and over 90 per cent positive at 14 years of age. More recent surveys suggest that these figures would seldom be found now even in large industrial towns, although such figures as are available show a very high infection rate in the war-ravaged countries of Europe and in the urbanized aggregates of primitive peoples in Africa and elsewhere. There is a marked difference in the tuberculin-positive rates according to social position, particularly in the age-groups of childhood and early adult life. For example, Long and Seibert (1937) report about 45 per cent of nearly 20,000 American college students as tuberculin positive at ages of 15–20 years, whereas Hetherington and his colleagues (1934) found 83 per cent positive in the same age-group in the Philadelphia schools. An even more striking difference is seen in the survey figures of urban, compared with rural, dwellers. Several surveys of rural dwellers in the United States of America show that in the age-group between 15 and 20 years, 30 per cent would be an average figure of those who are tuberculin positive. In the natives of Natal, Dormer, Friedlander and Wiles (1943) give figures for all ages of 40 per cent positive in rural dwellers and 80 per cent positive in urban dwellers. It must again be stressed that all these tuberculin test surveys only indicate the infection rate in any given age-group. They give no indication of the morbidity rate except in a negative sense; that is, the morbidity rate in a preponderantly tuberculin-negative group will clearly be low because the infection rate is low, but the converse, that the morbidity rate in a preponderantly tuberculin-positive group will be high, is quite untenable.

Comparison of urban and rural surveys

(b) *Morbidity judged by x-ray examination*

An x-ray examination of the chest, whether full-size or miniature film is used, will give, in the hands of competent observers, the most accurate method at present available for building up morbidity rates of pulmonary tuberculosis. The method is not, of course, as simple as it might at first seem. There is much disagreement as to the significance and interpretation of

certain x-ray shadows, so that it is not always possible to state categorically whether a certain picture denotes active disease or whether clinical tuberculosis, either past or present, can be diagnosed. Wilson and Miles (1946) say, "What proportion of latent lesions progress to a stage at which they give rise to clinical tuberculosis is at present unknown".

Surveys by x-ray

Hitherto, x-ray surveys have in the main been confined to particular groups of the population. World War II provided the first great stimulus to this method of surveying morbidity among Service personnel—clearly a selected group. The method is now being developed all over the world on civilian populations, chiefly urban, in whom the incidence of clinical tuberculosis is likely to be highest. The primary object of these surveys is case-finding and they are unlikely in the foreseeable future to give any over-all morbidity rates. All that can be hoped for is an indication of morbidity rates from sample surveys.

Object of surveys

(c) *Morbidity judged by post-mortem examination*

Since Naegeli reported in 1900 that evidence of tuberculous infection could be found *post mortem* in virtually every adult, it has been accepted that almost all persons of adult age have become infected with the tubercle bacillus and will show a demonstrable lesion *post mortem*. Carnes, in 1942, found lower figures in post-mortem examinations of adults in Baltimore, but the number was still approximately 80 per cent. These figures apply to persons dying in hospital and are therefore somewhat selective. It must again be stressed that these post-mortem findings are indicative of infection and not necessarily of clinical tuberculosis.

(d) *The degree of exposure to infection*

The effect of the degree of exposure to infection on morbidity rates is of the highest importance. Many workers have shown a much higher morbidity and mortality in children exposed to continued infection in the home with a case of open tuberculosis than in children with whom no open case of tuberculosis exists. When the home contact is with a case of tuberculosis not excreting tubercle bacilli, the incidence of tuberculosis in children is not statistically greater than in those not exposed to case contact. This increased risk of developing tuberculosis when there is home contact with a case of tuberculosis excreting tubercle bacilli is not confined to childhood, but is seen less dramatically in the older age-groups.

Home contacts

The reports of an increased morbidity risk for nurses and medical students, who are repeatedly exposed to tubercle bacilli, are conflicting. Some reports state that there is increased morbidity compared with the rest of the population; others deny this.

Nurses and medical students

(e) *Mode of infection*

The route of entrance of tubercle bacilli is important, because it decides the type of infection and disease which may follow. If we ignore infection by direct inoculation, which may or may not lead to local disease, and congenital infection of the foetus from the mother through the placenta, for which there is no convincing evidence, the main portals of entry are through the respiratory and the abdominal tracts. One school of thought postulated

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that infection almost always takes place through the mucosa of the intestinal tract, even when the clinical manifestation of tuberculosis is pulmonary. Although much experimental evidence was produced to support this theory, there are few people today who would subscribe to this view.

It is significant that tuberculosis due to the bovine type of tubercle bacillus is almost always non-pulmonary and is far commoner in children than in adults. The vehicle for infection with the bovine type is almost exclusively milk from tuberculous cattle and infection must therefore take place through the intestinal tract. Pulmonary tuberculosis in man is almost exclusively due to the human type of bacillus and from the pathological anatomy of the disease it seems reasonable to assume that the portal of entry is the respiratory tract. Pulmonary tuberculosis due to the bovine type of tubercle bacillus is uncommon and infection can almost always be traced either to another case of pulmonary disease due to the bovine type, or to intimate personal contact in those associated with tuberculous cattle, in which case infection through the air passages is an obvious risk.

Milk

Intestinal tract

Respiratory tract

The relative importance of dust and droplets in respiratory infections has given rise to much controversy. It is a matter of some importance in health propaganda to know which is the more important. If dust is the more important vehicle of infection, then the public should be taught not to infect the dust by spitting. If droplets are the more important, then people should be taught not to cough or sneeze in public. Wilson and Miles (1946) make the point that in most temperate countries the air is seldom dry enough to cause complete desiccation of sputum, which is necessary if dust is to be the vehicle of infection. Although specimens of dust from rooms in which contamination might be expected can frequently be shown to contain viable tubercle bacilli in culture, unless the sputum is dry the dust will not carry the moist particles when disturbed. They believe that droplet infection is far commoner in temperate climates.

Infection by dust and droplets

Smith (1942) has made a series of experiments on the effect of light on the viability of tubercle bacilli outside the animal body. His conclusion is that it seems probable that unfiltered day-time room-light can play a very important role in preventing cross-infections and in protecting the staff of tuberculosis sanatoria and rest houses.

(3) Pathogenesis of pulmonary tuberculosis

Two types of pulmonary tuberculosis, childhood and adult, have long been recognized. In children, the primary lesion is in the substance of the lungs; it is of focal type with a secondary involvement, including caseation and calcification, of the regional lymphatic glands. There is no particular localization and little tendency to fibrosis or cavitation in the lungs. In adults, there is a tendency to localization in the apex of the lungs without involvement of the regional lymphatic glands, but with fibrosis and cavitation in the lungs. Much evidence has been produced to show that the apical disease in adults is not an extension of the focal disease of childhood but a re-infection later in life. When the mortality from tuberculosis was much higher in the Western countries of the world than it is now, and almost all children had become infected before they reached adult life, the development of the adult type of pulmonary tuberculosis was ascribed to acquired immunity from childhood

Primary lesion in children

In adults

infection. This view is no longer tenable. A significant proportion of children now reach adult life uninfected with the tubercle bacillus, yet the childhood type of pulmonary tuberculosis is very rarely seen in adults of Western countries. On the other hand, the childhood type of tuberculosis is far commoner in the adults of primitive peoples when they are subjected to the rigours of Western urban life. The adult natives in southern Africa transplanted to the towns almost always develop the childhood type, yet in their native reserves, under tribal conditions, they more frequently show the adult type. It seems more likely that the adult type of pulmonary tuberculosis is more dependent on some biological change associated with age than with acquired resistance due to previous infection. Perhaps the development of the childhood type in adults of primitive peoples may be due to the effects of trying to graft centuries of Western civilization in one moment on pastoral races, with a consequent biological breakdown.

Biological change

(4) Bovine tuberculosis

Incidence

In man, the incidence of tuberculosis due to the bovine type of tubercle bacillus varies greatly in the countries of the world and is dependent upon the incidence of tuberculosis in cattle and the quantity of raw milk which is drunk. It is estimated that the bovine type of tubercle bacillus is responsible for 6 per cent of all deaths from tuberculosis in Great Britain, but it is certain that the percentage of deaths in children is very much higher, possibly 30 per cent. Surveys of groups of children suffering from tuberculosis in England and Scotland have shown that the incidence of the bovine type varies with the site of the disease. In England, 90 per cent of the cases of cervical gland tuberculosis, 25 per cent of cases of tuberculous meningitis and 30 per cent of cases of bone and joint tuberculosis in children up to the age of 5 years were all due to the bovine type. In Scotland, all the percentages were higher. In the United States of America, tuberculosis due to the bovine type is very rare and is virtually confined to some rural areas. In Toronto it has not been seen for 30 years. In South Africa it is very uncommon, probably due to the fact that little raw milk is drunk. The proportion of tuberculin-positive cattle is high in some areas in South Africa, although udder infection seems to be uncommon.

Incidence in cattle

The incidence of tuberculosis in cattle is probably higher in Great Britain than in any other country in the world and pasteurization of milk is even now far too uncommon. It is estimated that some 40 per cent of all cows in milk are infected with tuberculosis and that as many as 0 5 per cent of cows excrete tubercle bacilli in their milk. This means that about 7 per cent of samples of milk from individual farms contain tubercle bacilli.

Heat treatment of milk

It cannot be stressed too strongly that human tuberculosis of bovine origin can be eradicated. There is irrefutable evidence that tubercle bacilli in milk can be killed by heat treatment, w ... loss of nutritive value of the milk so small as to be negligible. It is only ... quote the evidence of Toronto, where, for 30 years, all milk cons ... city has been pasteurized. No case of tuberculosis of bovine orig ... seen, in spite of the fact that a quarter o ... s of pooled raw ... to the cit ... , tubercle bacilli. F ... of animal ... hus ... , should be to era ... , from mi ... his po ... adopted

for many years in the United States of America, coupled with compulsory pasteurization of milk. A similar policy has been started in Great Britain, but clearly, with an incidence as high as it is, it must be many years before the object will be achieved. The Government has taken powers under the Milk (Special Designations) Act, 1949, to specify areas in which the retail sale of milk is confined either to pasteurized milk or to that from tuberculin-tested herds. This Act came into force on October 1st 1949. It will clearly be some years before the whole country is covered by the specified areas. Meanwhile thousands of preventable deaths from tuberculosis of bovine origin continue and will continue until the milk supply is rendered safe.

5. DIAGNOSIS

(1) Bacteriological

As in all infectious diseases, the demonstration of the infecting organism in tuberculosis is the only absolute criterion. A clinical diagnosis of tuberculosis can often be made with almost complete certainty, but demonstration of the tubercle bacillus is the only certain method.

Microscopy

Tuberculosis can often be diagnosed by microscopical examination alone. Acid-fast bacilli of typical morphology seen in a film of certain pathological products of the body are almost always tubercle bacilli, but it must be remembered that staining alone will not differentiate between the tubercle bacillus and the other types of mycobacteria, including the common saprophytic acid-fast bacteria. Particular care must be taken to avoid a mistaken diagnosis with urine, in which the smegma bacillus can closely simulate the tubercle bacillus; with stomach washings, in which saprophytic acid-fast bacilli are not infrequently seen, and with faeces. In these cases the bacilli should either be isolated in pure culture or a pathogenicity test in a susceptible animal should be carried out.

Examination of sputum

In pulmonary tuberculosis the examination of sputum may often show typical acid-fast bacteria. If there is no available sputum, particularly in children, stomach washings or laryngeal swabs are useful procedures. Tuberculous pus frequently contains very few tubercle bacilli and any specimen of pus which appears on microscopical examination to contain no bacteria should always be suspected of being tuberculous in origin. Acid-fast bacilli in cerebrospinal fluid can be taken as almost certainly diagnostic of tuberculous meningitis.

Pus

Cerebrospinal fluid

(2) Animal inoculation

Guinea-pig inoculation

Probably the most sensitive diagnostic procedure in tuberculosis is guinea-pig inoculation Morbid material, containing only very few tubercle bacilli, will give rise to progressive disease when injected subcutaneously or intramuscularly in the guinea-pig. The guinea-pig is equally sensitive to the human and bovine types of tubercle bacillus. Differentiation between the types of tubercle bacillus is outside the scope of this article.

Comparison of methods

Many surveys have been made to compare the relative delicacy of animal inoculation and cultural methods. The balance seems to be slightly in favour of animal inoculation. Both methods should be used if the greatest possible number of positive results are to be obtained.

(3) Serological methods

Serological methods of diagnosis have so far been of little help. Many methods have been tried, but the lack of specificity in all the tests has rendered them valueless. Attempts have been made to prepare an agglutinable suspension of tubercle bacilli, but so far without success. Complement fixation, although having some strong protagonists, is equally disappointing. Middlebrook and Dubos (1948) have recently described a technique of sensitizing red cells with carbohydrate prepared from the tubercle bacillus. The test is as yet unproven, but it appears promising.

(4) Allergic reactions

Negative reaction

Positive reaction

The reaction of the skin to old tuberculin or to purified protein derivative has already been described. The use of the tuberculin test in diagnosis is greatest in childhood, but is of value in adult life. A negative reaction to an intradermal injection of a dilution of 1 : 100 old tuberculin or an equivalent amount of purified protein derivative virtually excludes a diagnosis of tuberculosis at any age. A positive tuberculin reaction does not indicate whether the reactor has an active or an inactive lesion. It is merely an indication that the reactor has at some time been infected with the tubercle bacillus, although it is certain that some positive reactors may revert to negative. A positive reaction in childhood, particularly early childhood, is strongly suggestive of active tuberculosis, but here again a negative reaction is probably of more diagnostic value, in that tuberculosis can be excluded.

6. IMMUNITY

(1) Species resistance

Variations in resistance

There is an enormous literature about immunity in tuberculosis—or, more properly, resistance to tuberculosis—but our knowledge of the subject is so small that the mechanism of resistance remains entirely unsolved. Knowledge of certain facts would lead to the belief that experiments should be able to determine the nature of the defence mechanism. We know that some species of animals are more resistant to infection with the tubercle bacillus than other species. We know that within this range of resistance are certain species almost wholly resistant and others almost wholly susceptible. Animals which show these extremes are easily kept laboratory animals, such as the rat and the guinea-pig. The rat is almost completely resistant; the guinea-pig has little, if any, resistance. What accounts for the resistance of the rat and the susceptibility of the guinea-pig? Should it not be possible to demonstrate some difference either in the cells or the tissue fluids of the two animals which would account for this variation? These questions remain unanswered.

There are further questions of vital importance which arise from the variation in resistance of species to the various types of tubercle bacilli. For example, why is the rabbit relatively resistant to the human type of tubercle bacillus as compared with the guinea-pig, while both are susceptible to the bovine type? Why is the rabbit susceptible to the avian type and the guinea-pig completely resistant? Why is the fowl susceptible to the avian type, yet resistant to the human and bovine types? These questions could be multiplied

many times. It seems to be quite impossible to predict without experiment what is the species resistance to any one type of tubercle bacillus.

Much experimental work has been done in an effort to determine what are the requirements of each type of tubercle bacillus to multiply and cause progressive disease in the animal body, and what is responsible in the resistant species for the prevention of progressive disease. It has not yet been shown that any of the requirements of the tubercle bacillus to multiply *in vitro* are absent *in vivo*. It seems clear that neither the temperature of the animal body alone nor the known composition of the tissue fluids nor any demonstrable alteration in the cells is responsible for resistance. The blood serum of animals resistant to tuberculosis will readily support growth of the bacilli *in vitro*. Several workers have shown that tissue cultures of pieces of organs from animals resistant to tuberculosis allow tubercle bacilli to multiply *in vitro* in the same way that cultures of pieces of organs from susceptible animals do. It is not possible to demonstrate in tissue culture any difference of behaviour between pieces of spleen from the rabbit and from the guinea-pig, when both are infected with a human type of tubercle bacillus. Yet we know that the reaction of the two species *in vivo* to the human type is markedly different. It is not, of course, reasonable to assume that a small explant of animal tissue will behave *in vitro*, under conditions greatly differing from natural conditions, as it does *in vivo*. *Tissue cultures*

Nevertheless, it is remarkable that neither the cells nor the tissue fluids of naturally resistant and naturally susceptible species should show dissimilar reactions to the tubercle bacillus *in vitro*. We know that tubercle bacilli are segregated very soon after entry to the animal body in the mononuclear phagocytes, whatever organ may be the site of infection. It seems likely, therefore, that conditions within these cells must largely decide whether or not progressive disease follows. It is of vital importance to know in what way the growth requirements of the several types of tubercle bacillus differ; whether the types have different mechanisms for obtaining nutritive materials from their environment; whether any differences exist between the sensitivity of the different types to cellular metabolic products; and whether a type of tubercle bacillus to which an animal is resistant provokes a change in *p*H inside the phagocyte that differs from that incited by a type to which that animal is susceptible.

What place does man occupy in the range of species resistance? Clearly, man is not wholly resistant; he is also not wholly susceptible. It must be assumed that all adults at some time during life will meet infection, certainly those living an urban life and the majority of those living a rural life. This can be shown by the development of tuberculin sensitivity. If the reaction of man to the tubercle bacillus were similar to that of the guinea-pig, for example, then infection would in all cases lead to progressive disease. This we know is not the case, so it must be concluded that man has some degree of species resistance to the tubercle bacillus.

(2) Racial resistance

We have so far been considering natural, or native, species resistance, and have seen how wide is the variation between species and species. A similar, though perhaps less spectacular, variation occurs in the races of a species.

This can be called racial native resistance. There is, for example, a great difference in resistance in the mouse tribe. The white mouse shows a relatively high resistance to all the types of tubercle bacillus compared with the vole, which is highly susceptible to infection with the bovine type and with the murine type, the latter of which is endemic among voles in nature. The variation in resistance of different breeds of rabbit and groups of cattle has already been mentioned Is there a similar variation in racial resistance in man? This question has been discussed earlier in this article. It seems reasonable in our present state of knowledge to conclude that a variation in native racial resistance in man does exist, but the importance which such resistance should be given in racial morbidity is indeterminate.

(3) Individual resistance

The native individual resistance to tuberculosis shows a variation every bit as baffling as species or racial variation. Every laboratory worker knows that individual guinea-pigs—an almost wholly susceptible species—show a wide variation in the extent of the disease process, even when the infecting dose of tubercle bacilli is similar and synchronous. The same is true of individual cows. A striking difference in individual native resistance occurs in man. We know that a child meeting infection with the tubercle bacillus for the first time can react in one of three ways: infection may be progressive, causing a tuberculous lesion which becomes generalized and leads to death; infection may lead to a localized disease which either heals or becomes inactive; or infection may not give rise to a demonstrable change in the body other than a sensitization to tuberculin. It may even be true that there is a fourth type of reaction. It is possible that individual native resistance may be responsible for destruction of the bacilli without infection ever taking place and therefore without the development of sensitivity. The baffling question in tuberculosis remains: why do only a small percentage of individuals who are infected exhibit progressive disease?

Types of reaction

(4) Acquired resistance

Development of acquired resistance after infection with certain bacteria is so high as virtually to amount to complete immunity. The extent of acquired resistance after infection with other bacteria is so small that it is barely demonstrable. Does infection with the tubercle bacillus produce an enhanced resistance to subsequent infections? This question has been, and still is, hotly debated. Obviously, it is a question of great importance in the policy of combating the disease. One school of thought points to the number of cases in which a primary infection, after remaining quiescent for many years, flares up and leads to progressive disease, and to those cases which have resisted primary infection only to fall victims to subsequent infection, postulating therefrom that infection is always deleterious and that the aim should be to [illegible]

[illegible]

[illegible]

whether enhanced resistance has followed, lies [illegible] demonstrating the degree of resistance of any individual. There is no laboratory test for resistance.

If it is possible to draw conclusions in man from the effect of infection in animals, then it is certain that enhanced resistance does follow infection. Some degree of enhanced resistance in the guinea-pig follows the injection of a virulent or dead tubercle bacilli, as measured by the survival time after infection with virulent bacilli in those inoculated and those uninoculated. It is, however, dangerous to assume that what occurs in the guinea-pig occurs in man. Tuberculosis in the guinea-pig is very different from that seen in man. Absolute immunity does not occur in susceptible animals by any means at present available, nor clearly does it occur in man after primary infection.

It is not possible even to mention the many arguments that have been put forward for and against the development of acquired resistance in man. Rich (1946) discusses the question at length and concludes that the evidence in favour of some measure of acquired resistance is irrefutable.

(5) Allergy

It has already been stated that a susceptible animal infected with tubercle bacilli develops a hypersensitivity to old tuberculin, a product of tubercle bacilli *in vitro*, and that the protein fraction of the bacillus is the one responsible for eliciting the hypersensitive skin reaction. The hypersensitive animal or man shows a tissue response to the tubercle bacillus which differs from that of the non-sensitive animal There is an accelerated inflammatory response and a relative inhibition in the multiplication of the bacilli What is the relation between hypersensitivity and acquired resistance? There are two opposing views. One view is that hypersensitivity and acquired resistance go hand in hand; the other holds that acquired resistance is not dependent on the development of hypersensitivity and can be present in the absence of hypersensitivity. These views are based on experimental evidence and observations in man. The evidence on both sides can be read in the writings of Rich (1946) and of Wilson and Miles (1946) Whether hypersensitivity in itself is beneficial in resisting tuberculous infection or not, it is quite certain that the degree of hypersensitivity is not a measure of the degree of acquired resistance.

Relation between hypersensitivity and acquired resistance

(6) Non-specific factors in resistance

Acquired resistance as a result of infection with the tubercle bacillus is dependent on changes in the body specific to that infection. This specific acquired resistance, if indeed it is accepted as a fact, is due to changes in the tissues which specifically retard the development of infection or disease. The tissue changes in any bacterial infection can usually be demonstrated by the development of antibodies which are either circulating in the blood or can be rapidly produced by the tissues when the specific organism gains entrance to the body. Although demonstration of antibodies in tuberculosis is unsatisfactory and is apparently unrelated to resistance, yet their presence must be assumed if specific acquired resistance is accepted. What, then, is the relative importance, in resistance to tuberculosis, of specific acquired resistance and of the physiological state of the body when the tubercle bacillus is encountered? Is specific or non-specific resistance of most importance? The answer to this question is of primary importance to those concerned with prophylaxis.

The effect of nutrition, housing, overcrowding, physical and mental strain

Social factors

and occupation on the development of tuberculosis has been intensively studied, but it cannot be said that scientific proof has often followed investigation. There is much circumstantial evidence that all these factors contributed to the increase of tuberculosis during the two World Wars in all the countries of Europe. The increase of tuberculosis in primitive peoples when uprooted from their natural conditions to urban life, with the consequent bad social and environmental conditions, has already been noted. The increase in morbidity may be partly due to increased exposure to infection but it is unlikely that this is the major factor. The decrease in mortality from tuberculosis in all the countries of Western civilization over the past 50 years has coincided with a raising of the standards of general hygiene and nutrition. It is difficult not to accept that the better conditions are major factors in the increased resistance.

7. PROPHYLAXIS

Avoidance of infection

It follows from what has already been said that the best method of prophylaxis is to avoid infection. This is the ideal at which to aim, but it clearly cannot be realized for a long time. The segregation of infectious cases, early case-finding by mass x-ray surveys and the careful and continued examination of contacts have all helped to reduce the morbidity and mortality rates, but there is still an enormous reservoir of undetected infectious and potentially infectious cases at large. If, then, avoidance of infection is at present impracticable, what methods are available for increasing resistance to infection? The bettering of social conditions, which may be called a non-specific factor, has been mentioned and is probably of the greatest consequence. There remains the possibility of increasing specific resistance by vaccination.

Vaccination

Ever since the discovery of the tubercle bacillus by Koch, efforts have been made to produce a vaccine which will increase resistance to subsequent infection with virulent tubercle bacilli. If it is accepted that infection increases resistance, then the aim must be to induce either a controlled infection by means of a vaccine of bacilli which will not produce progressive disease or to increase specific resistance by a vaccine of killed bacilli or some part of the bacilli. Numerous experiments have been done in animals with killed vaccines and avirulent live vaccines. As a generalization, it can be affirmed that vaccination in animals will increase resistance to subsequent inoculation with virulent tubercle bacilli, as measured by the survival time after infection with virulent tubercle bacilli.

Vaccine of dead bacteria

The use of vaccines of dead tubercle bacilli was the first to be tried, when it had been found that vaccines of other dead bacteria were in some instances capable of greatly enhancing resistance or even producing immunity to the specific organism concerned. When it was found that a vaccine of dead tubercle bacilli was incapable of producing in animals a degree of resistance comparable with that produced by other bacteria, the method was aban-

[illegible] that

[illegible]

may well be impracticable. It is certainly true that no method of [illegible]

tried up to the present can produce immunity in guinea-pigs, the laboratory animals most used in such experiments. The question naturally arises, can immunity experiments against tuberculosis in guinea-pigs be translated into comparable terms in man? It is quite unjustifiable to think that they can. It has already been remarked that the guinea-pig is a species without native resistance, whereas the same is not true of man. Further, tuberculosis in the guinea-pig has not the same natural history as in man. Even if the experience in animal experiments could be related to man, there remains a fundamental difference. Animal experiments have almost exclusively been conducted so that the infecting dose has been one injection, usually by a route quite foreign to natural experience. It is probable that the exposure to infection in man is repeated and is variable in weight from individual to individual and from time to time. The usual history in a case of tuberculosis is exposure over a period of time to an open case. Little attempt has been made to conduct animal experiments under field conditions at all comparable to those associated with human tuberculosis. Whether such conditions are more or less exacting on the body defences than the conditions of experiment, it is difficult to say.

Effect of route of infection

Bacillus of Calmette and Guérin

Attempts to raise resistance to tuberculosis by dead vaccines were given up and alternative methods sought. Calmette (1927) believed that a vaccine of living tubercle bacilli, sufficiently attenuated not to produce progressive disease, was essential to raise resistance. He and Guérin introduced a strain of the bovine type of tubercle bacillus, which had been cultured in the laboratory for some years on a medium containing bile. This they called B C G. They showed that it was incapable of producing progressive disease in susceptible animals. After a number of animal experiments, which seemed to show that resistance was raised, the vaccination of human beings was started. As this was to be a prophylactic measure, Calmette vaccinated infants very soon after birth. It is not necessary to discuss the original experiments in detail. The results are, by common consent, inconclusive.

Culture

B C.G. has now been used very extensively in man in most countries of the world. A number of different methods of giving the vaccine have been tried. Calmette gave the vaccine by mouth, a method now abandoned owing to the uncertainty of infection following oral administration. Subcutaneous and intradermal injection, scarification and multiple puncture have been tried Subcutaneous injection has been abandoned owing to the high incidence of local ulceration following injection. Vaccination by intradermal injection and multiple puncture is now most used. The aim of vaccination with B.C.G. or any other living vaccine is to produce an infection which will not produce general disease and will give rise to as small a local and general reaction as possible. This controlled infection is aimed to replace the naturally occurring primary infection of tuberculosis which clearly must be uncontrolled. The persons to be vaccinated must obviously be uninfected—that is, they must have a negative reaction to the tuberculin test. As a result of vaccination, hypersensitivity should follow, not for the sake of rendering the person hypersensitive, but as an indication that infection has in fact taken place, without which it is difficult to believe that resistance has been raised.

Methods of administration

Controlled infection

Hypersensitivity

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tried up to the present can produce immunity in guinea-pigs, the laboratory animals most used in such experiments. The question naturally arises, can immunity experiments against tuberculosis in guinea-pigs be translated into comparable terms in man? It is quite unjustifiable to think that they can. It has already been remarked that the guinea-pig is a species without native resistance, whereas the same is not true of man. Further, tuberculosis in the guinea-pig has not the same natural history as in man. Even if the experience in animal experiments could be related to man, there remains a fundamental difference. Animal experiments have almost exclusively been conducted so that the infecting dose has been one injection, usually by a route quite foreign to natural experience. It is probable that the exposure to infection in man is repeated and is variable in weight from individual to individual and from time to time. The usual history in a case of tuberculosis is exposure over a period of time to an open case. Little attempt has been made to conduct animal experiments under field conditions at all comparable to those associated with human tuberculosis. Whether such conditions are more or less exacting on the body defences than the conditions of experiment, it is difficult to say.

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Methods of administration

Controlled infection

Hypersensitivity

B.C.G. is a virulent tubercle bacillus rendered avirulent by cultivation. There is no evidence that its virulence can be raised by any means, so as to render it pathogenic. Many millions of persons have been vaccinated with B.C.G. and no authentic instance of progressive disease has followed vaccination. The former fear that B.C.G. might, under some conditions, again become pathogenic has changed to a fear that virulence may become so reduced that it is no longer antigenic. B.C.G. is not a naturally occurring pathogen, so that its virulence cannot be maintained by animal passage.

Murine type

The murine type of tubercle bacillus, or the vole bacillus, has been described by Wells (1946) as a natural pathogen of voles. This bacillus is not pathogenic to laboratory animals or to cattle and its use in man as a living vaccine has not given rise to progressive disease in the relatively small number of persons who have been vaccinated. Experiments in guinea-pigs and cattle show that resistance to subsequent infection is increased, an increase reported as being greater than that conferred by B.C G. but not amounting to immunity. Results in man warrant an extended trial. The murine type of tubercle bacillus has the advantage over B.C.G. in that it is a natural pathogen of voles not reduced in virulence by laboratory methods and that its virulence can be maintained in the laboratory by animal passage.

Effect on resistance

Does B.C.G. or the murine type of tubercle bacillus increase the resistance of man to tuberculosis? In spite of the huge number of persons who have now been vaccinated, it is still impossible to give a categorical answer. Scientifically controlled experiment in human vaccination against tuberculosis is exceptionally difficult and none of the experiments described satisfies the statistical purist. It is generally believed in Scandinavia and France that enhanced resistance follows vaccination and it would be difficult to deny such a probability. Critics of the use of vaccination remain unconvinced, and it is much to be hoped that carefully planned experiments will give an answer. A reasonable attitude to the problem of vaccination would be that it probably raises resistance, but can only be regarded as one of the means of doing so and perhaps not the most important means. Prophylactic measures against tuberculosis may well include vaccination, but if they depend on vaccination alone they will almost certainly fail.

Attempts have been, and are being, made to break down the tubercle bacillus *in vitro* so as to find a potent antigenic fraction which will raise resistance. No fraction has so far been found to be as potent as the whole bacillus.

8. CHEMOTHERAPY

The history of tuberculosis is full of reports of drugs which are more lethal to the tubercle bacillus *in vivo* than to the body tissues. The desire to find such a drug has activated many research workers. The discovery of the sulphonamide group of drugs and particularly of penicillin, which have little effect on the tubercle bacillus *in vivo* by any means of administration so far devised, greatly stimulated the search for something effective against tuberculosis. The first group to be studied was the sulphones, which have marked

... Feldman Hinshaw

[illegible]ffect of [illegible]min

on experimental tuberculosis in guinea-pigs. There was a striking [illegible]

development of the disease in those animals receiving the drug, but toxic effects were marked and a considerable proportion of the animals died from the effect of the drug. The use of promin in man is generally disappointing and the toxic effects are severe. Other sulphones, promizole and diazone, were tried and, although the toxic effects were less and the clinical results better than with promin, it was clear that none seemed likely to be of any great value in tuberculosis, especially as the whole sulphone group is known to be more or less toxic. In 1944, Waksman, Bugie and Schatz isolated streptomycin, an antibiotic extracted from an actinomyces. They showed that streptomycin has a low toxicity for animals and a high inhibitory power against the growth of tubercle bacilli *in vitro*. Feldman and Hinshaw (1944) reported their results with streptomycin in guinea-pigs infected with a human type tubercle bacillus. These were striking and promised useful results in human tuberculosis. Since that time a flood of reports has been published on the results of streptomycin treatment in man, both in tuberculosis and in other infectious diseases in which the causative organism is insensitive to penicillin The first reports mentioned some untoward toxic manifestations, notably an affection of the labyrinth which seemed to be irreversible after streptomycin therapy had stopped. It has since been shown that these toxic effects were due to impurities in the extraction process; they have been largely abolished with increased purification.

Promizole and diazone

Streptomycin

Early toxic manifestations

Results of streptomycin therapy

The results of streptomycin therapy in tuberculosis can be considered under two heads—the results in the treatment of tuberculous meningitis and of other forms of tuberculosis.

Recovery from tuberculous meningitis without chemotherapy is so rare that controls for the series treated with streptomycin are unnecessary. The Medical Research Council recently published a report on 105 cases of tuberculous meningitis in Great Britain treated with streptomycin. Of these cases, 71 had died, 27 were doing well after a period varying from 4 months to 2 years, and the remaining 7 were either stationary or deteriorating The figures are comparable to the other reports on the results of streptomycin treatment of tuberculous meningitis. A striking improvement in the prognosis was shown when the diagnosis was made and treatment was started early in the disease When treatment was delayed until a late stage of the disease the results were very much worse. Intramuscular injection of streptomycin in tuberculous meningitis is insufficient and must always be accompanied by intrathecal or intraventricular injection The length of time during which treatment must be continued is not yet determined, but it seems necessary to persevere for several weeks or months if relapse is to be avoided.

Tuberculous meningitis

Early diagnosis and treatment

The results in cases of miliary tuberculosis are also promising Perhaps the most striking clinical improvement is seen in cases of tuberculous laryngeal ulceration and tracheobronchial ulceration and cutaneous sinuses. The results in pulmonary tuberculosis are much more difficult to assess. Inconclusive results have been reported in genito-urinary and bone and joint tuberculosis.

Miliary tuberculosis

Pulmonary tuberculosis

It was early recognized that *in vitro* the tubercle bacillus rapidly developed resistance to streptomycin. After only a few subcultures, up to 1,000 times the concentration of streptomycin was needed to show inhibition of growth.

Development of resistance

Furthermore, once this resistance had developed it was irreversible. The same degree of resistance occurs *in vivo*. A recent report by Crofton and Mitchison (1948) on the development of resistance shows that before treatment with streptomycin the resistance of the tubercle bacillus is remarkedly uniform. After a period of treatment varying from 48 to 189 days, 12 of the 13 strains isolated had developed resistance to streptomycin varying from 3 to more than 10,000 times that before treatment was started. With one exception, the change was of such a degree that the concentration of the drug in the tissue could not inhibit growth. It seems that the sooner resistance develops, the greater will it eventually become. It also looks as if persons whose bacilli develop resistance late in treatment derive more benefit from streptomycin. However, the development of resistance of the tubercle bacilli *in vivo* is not necessarily related to clinical progress. It may be that the pursuit of streptomycin treatment after resistance has developed is fruitless, but that in some cases the patient may have been sufficiently improved by treatment to continue overcoming the infection. The development of resistance of the infecting organism in tuberculous meningitis appears to be much less common than in other forms of tuberculosis.

Mechanism of acquired resistance

The mechanism of acquired resistance of the tubercle bacillus is not known. There is some evidence that among the bacilli isolated in culture from a case of pulmonary tuberculosis are some of higher resistance than the majority. The resistant bacilli, seen after streptomycin treatment has been in progress for some time, may be the result of a few bacilli originally resistant and able to multiply in the body while the non-resistant bacilli have been destroyed, or they may result from an acquired resistance of those bacilli that are in tissues in which the concentration of streptomycin is insufficient to inhibit their growth. There is a theoretical danger in the future of resistant strains of tubercle bacilli becoming the predominant race in fresh infections. There is strong evidence that streptomycin resistance is a permanent change, in which case streptomycin therapy would become valueless. It seems that there is a real danger in the indiscriminate use of streptomycin for all and every case of tuberculosis. There is probably more need for clinical discrimination than in any other disease.

Future danger

Streptomycin is clearly not the ideal antibiotic for tuberculosis. There is hardly a country in the world that is not today feverishly trying to find the drug that will destroy the tubercle bacillus *in vivo*. Seeing the astonishing progress towards this end that has been made in the past few years, who can say that the ideal is impossible of attainment?

9. CONCLUSION

The fall in the death rate from tuberculosis over a period of years has led to a certain complacency. The fact remains that tuberculosis is an infectious disease which is closely associated with the social and environmental evils of Western civilization. So long as these evils remain, so long will tuberculosis remain one of the major causes of death. Even in the United States of America, where environmental conditions are probably better than in any country in the world, tuberculosis is still by far the commonest cause of death in the 15–45 age period. As Rich (1946) rightly says, "The disease that still

kills more than twice as many individuals as any other single cause of death during this particularly productive and enjoyable period of the life span can hardly be jubilantly regarded as being nearly conquered".

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[References to other titles are given under Tuberculosis in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol 12, p. 286]

TYPHOID FEVER, SURGERY IN

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Honorary Surgeon to H.M. The King; Consulting Surgeon, St. Thomas's Hospital, London; Major-General, A.M.S.T.A.

331.] Typhoid fever (typhus abdominalis) is a disease which may occur at any period of life and, generally speaking, the milder the attack the more liable is a patient to surgical complications, although it must be realized that it is not only in the ambulant type of case that these complications occur.

Surgical complications in the abdomen usually manifest themselves about the third week of the disease: there are two of these complications which are dramatic in their onset, and one which is less so.

1. PERFORATION

Usually, perforation occurs in a mild ambulant case of typhoid fever, often one which has not been recognized. The perforation is single as a rule, but more than one may be present in the lower two feet of the ileum, and is situated generally at the antimesenteric border at the edge of a thickened Peyer's patch. There is a sudden onset of pain in the lower abdomen and often the patient may collapse. *Site*

(1) Diagnosis

There is usually a history of some diarrhoea for a week or two and headaches may be complained of, an examination of the chest frequently reveals scattered rhonchi at the bases of the lungs. Spots may be present and should always be looked for. On examination, the abdomen usually is generally distended and doughy with marked tenderness and some rigidity in the right iliac fossa. In cases of severe typhoid infection, the general lethargic condition of the patient, or his degree of toxicity, may result in absence of abdominal rigidity. A point of some diagnostic significance is the slowness of the pulse relative to what would be expected in such obvious peritoneal infection; the temperature, if it has been charted, will have been of the remittent type, about 100°–103° F. and will drop abruptly to subnormal with a perforation and then rise again in a few hours as peritonitis becomes established There is little or no leucocytosis in these cases. If the patient is not operated on promptly, a virulent type of general peritonitis develops to which the patient has little or no resistance, so that the prognosis, serious in any case, is practically hopeless once the peritonitis is established. *History* *Pulse rate* *Prognosis*

(2) Differential diagnosis

The differential diagnosis is between pelvic appendicitis, salpingitis, and, in elderly patients, a perforation of an infected diverticulum of the colon into the general peritoneal cavity.

(3) Treatment

Treatment consists in immediate operation with suture of the perforation in the lower ileum, a proceeding which may be difficult to achieve successfully, as the bowel will be found congested and friable. A search of the lower ileum and caecum is necessary in case a second or even a third perforation should be present, but the bowel must be handled very gently. *Immediate operation*

(4) Post-operative treatment

The Widal reaction should be performed If necessary, gastric suction is instituted and radiant heat may be given to the abdomen Chemotherapy is of doubtful value in any case of typhoid fever, but hexamine, 15 grains thrice daily, is very valuable in controlling urinary infection; it should be given with alkalis to prevent frequency or strangury Sulphaguanidine or streptomycin *Hexamine*

derivatives given by mouth undoubtedly control putrefactive organisms in the bowel and may affect the *Bacillus typhosus.*

2. HAEMORRHAGE

The complication of haemorrhage occurs from the separation of sloughs in the lower ileum and caecum, usually about the third week of the illness, and often in ambulant cases. The haemorrhage is frequently preceded by a premonitory small loss of blood, but it may be very severe and cause complete collapse and even death. The patient feels giddy and sick and is white, with the pulse rapid and irregular and the skin cold and sweaty. If the case is one of known typhoid with lethargic mental state, a sudden fall of temperature may call attention to the patient's grave condition. Examination of the abdomen possibly reveals typhoid spots with distension; it may be doughy and tender under the examining hand.

Condition of patient

(1) Differential diagnosis

Differential diagnosis lies between a ruptured ectopic gestation (in a female) and haemorrhage from tuberculous ulcers in the ileo-caecal region, whilst rarely doubt may arise as to whether the patient is suffering from acute dysentery or cholera.

(2) Treatment

Treatment of haemorrhage from tuberculous ulcers and of dysentery or cholera is medical—rest, opiates, and, if necessary, reassurance. Diet will be confined to fluids if it is not already of that type.

(3) Prognosis

The prognosis in these cases is always serious.

3. CHOLECYSTITIS

(1) Acute

Acute cholecystitis *may, and not infrequently* does, occur about the third or fourth week of the attack of typhoid fever. It is usually of a mild type and does not call for special treatment, other than observation and the administration of alkalis and hexamine, 15 grains thrice daily, or the oral administration of Sulfasuxidine 0·5 gramme thrice daily or aureomycin 0·5 gramme daily.

(2) Chronic

Chronic cholecystitis, which is always to be suspected in any case after an acute infection has occurred during the course of an attack of typhoid fever, is quite frequently met with where no such history exists and it produces all the symptoms associated with chronic inflammation of the gall-bladder—epigastric discomfort, pain and a chilly feeling in the back, flatulence and a sense of fullness after meals—whilst at more or less frequent intervals active typhoid bacilli are passed in the patient's stools and may be detected

Symptoms

on bacterial examination. The condition may persist undetected for many years and is probably the most frequent site of trouble in typhoid carriers. Calculi may be formed ultimately in the gall-bladder and give rise to typical attacks of biliary colic. *Calculi*

(*a*) *Differential diagnosis*

Differential diagnosis lies between other forms of chronic cholecystitis, gall-stones and duodenal ulceration, and can be established by finding a positive Widal reaction, or by *B. typhosus* in the stools. An amoebic liver abscess, infected hydatid cyst, or chronic malaria may cause some difficulty in diagnosis. *Widal reaction*

(*b*) *Treatment*

Treatment consists in cholecystectomy after administration of hexamine, 15 grains, 3 times daily for 14 days, or aureomycin 0 5 gramme daily for 3 or 4 days

(*c*) *Prognosis*

The prognosis is good provided cholecystectomy is performed.

4. DISTANT COMPLICATIONS

Distant complications usually manifest themselves some time after the termination of the attack of typhoid fever, but they may occur during the acute attack, though often they may not be seen for many years.

(1) Arthritis

Arthritis may occur in the later weeks of the attack and produce very little pain owing to the weak condition of the patient's muscles precluding spasm around the affected joint. Such cases rarely proceed to suppuration and are frequently diagnosed only when the patient leaves the bed and it is found that some joint, often the hip, is dislocated and useless.

(*a*) *Differential diagnosis*

The diagnosis lies between the many other forms of subacute arthritis, notably rheumatism.

(*b*) *Treatment*

Treatment consists in maintaining the joint surfaces in proper apposition, in a position which would be useful should ankylosis occur, by suitable extension and plaster of Paris; whilst if suppuration has taken place, the pus must be evacuated by adequate incision, opening the joint at its most dependent part in the position in which the patient is being nursed. *Evacuation of pus*

(2) Fibro-fasciitis

Fibro-fasciitis is a rare complication of typhoid fever and is usually not manifested till late in the disease or during convalescence. It is manifested by pain and stiffness in the area affected, usually in the neighbourhood of the spine (typhoid spine) or in the soles of the feet when flat-foot may result.

It should be stated that some authorities regard typhoid spine as due to an *osteochondritis*, but x-rays give no positive evidence that this is the case.

(a) Differential diagnosis

The diagnosis lies between other forms of fibro-fasciitis, rheumatism, gonorrheal and possibly rheumatoid arthritis.

(b) Treatment

Treatment consists in rest combined with radiant heat, diathermy and the administration of aureomycin or similar substances. Massage, manipulations and exercises are to be avoided at any rate for several weeks.

(3) Thrombophlebitis

Thrombophlebitis is a not uncommon sequel of typhoid fever and may affect large veins such as the vena cava, in which case a compensatory circulation with dilatation of the superficial veins of the trunk and thorax gradually develops.

Treatment

Treatment does not differ from that for an infective thrombophlebitis under any conditions.

(4) Abscesses

Sites

Abscesses may occur in bone or cartilage in any part of the body, but probably the most common sites are the costal cartilages and the tibia where the development of a painful bony swelling during or after the attack of typhoid fever should always arouse the suspicion that there is an abscess in the cartilage or bone. There is usually no sign of any local infection other than the swelling mentioned, nor is there any general rise of temperature, but these patients may suffer from an earthy complexion, marked anaemia and a feeling of lassitude and lack of fitness. An x-ray examination will reveal an irregular cavity at the site of the abscess, with surrounding induration of the bone in chronic cases. If left alone, these abscesses gradually increase and may often discharge on the surface, when the fluid will contain active typhoid bacilli capable of causing a severe and extensive epidemic of typhoid fever.

X-ray examination

Treatment

The proper treatment is to open the abscess, curette out the cavity and swab it out with some strong caustic, such as fuming nitric acid, care being taken that this does not get on to the surrounding skin. All dressings must be carried out in rubber gloves and the soiled gauze is immediately burned. An abscess is sometimes met with at the site of injection of prophylactic serum. This does not contain typhoid bacilli and should be treated by incision as any other abscess. Oral administration of aureomycin or chloromycetin may be of value in destroying the *B. typhosus*.

(3) Infections of the kidneys

Public danger

Infections of the kidneys are not common, but they are particularly dangerous to the public, as the patient passes active typhoid bacilli in the urine and many

epidemics have resulted from this. The patient usually does not complain, though there may be a history of attacks of frequency. Generally, only one kidney is affected and this proves to be fibrotic, small and adherent to the surrounding tissue. Pyelography will be helpful in diagnosis. *Pyelography*

(a) Differential diagnosis

The diagnosis from other renal infections of a chronic nature can be established definitely by finding a positive Widal reaction or typhoid bacilli in the urine. The usual difficulty in these cases is to distinguish *B. coli* infection and this can usually be done by a microscopic examination of a spun specimen of urine or the culture of the bacilli on suitable media, while the rapidity with which the infection clears on the administration of sulphonamides or streptomycin will quickly establish that the infection is not due to the *B. typhosus.*

(b) Treatment

It is early yet to estimate the value of aureomycin or chloromycetin in sterilizing the urine in such cases, but only after a trial of these has failed should treatment consist of removal of the kidney, together with as great a length of the ureter as can be reached through the loin incision.

5. TYPHOID CARRIERS

From the above comments, it will be seen that a typhoid carrier from infection of the gall-bladder, of the kidneys, of the intestinal tract or of a discharging sinus from a bone abscess is a real source of danger to the public, and most typhoid epidemics can be traced to the presence of an undetected carrier in the community. It is essential, therefore, that all concerned in the handling of food or drink should have a Widal examination which is negative, and that a carrier should be sought for in the early stages of any typhoid epidemic, and, when found, isolated and treated

6. AUREOMYCIN, CHLOROMYCETIN AND HEXAMINE

Recent treatment by the biochemical substances chloromycetin and aureomycin apparently establishes that these have a specific action in combating the *B. typhosus*, though it must be realized that the administration of these by mouth, as also a similar use of streptomycin or sulphaguanidine, will largely combat the secondary infection in the stagnant bowel and so ensure considerable amelioration of the patient's abdominal distension and physical condition Apparently, however, chloromycetin and aureomycin are both capable of lessening the virulence of the infection, shortening the period of illness and improving the patient's general condition, both mental and physical.

Prior to the recent discovery of these substances hexamine has for many years been used systematically in the treatment of typhoid fever, and while

its inhibiting effect upon the activity of the *B. typhosus* does not appear to be permanent, it is a valuable deterrent to the activities of that organism both in the acute stages of the disease and for typhoid carriers.

[References to other titles are given under Typhoid Fever, Surgery in, in the Index Volume The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol. 5, p. 51.]

ULCERS AND ULCERATION

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1. DEFINITION

332.] *Ulceration* may be defined as molecular or cellular death of a covering membrane, but the term, though strictly applicable only to skin and mucous membranes, is used also in reference to deeper tissues, for example, atheromatous ulcers in large blood vessels. Usually phagocytosis can cope with and remove the dead tissue at a pace approximately equal to its destruction, but in the early stages with virulent infection, or if the blood supply is poor, a mass of dead tissue, the sphacelus, or slough, may be present on the surface of the ulcer.

2. AETIOLOGY

Association with infection

Ulceration is almost invariably associated with infection which is either introduced through a traumatic breach of the surface epithelium or is preceded by a localized thrombosis in the vein or artery, usually end vessels, which nourish the membrane. The aetiological micro-organisms vary greatly in their types, in their virulence and in the reactions which they cause in the surrounding tissues; hence there is considerable difference in the clinical picture seen in the ulcers resulting from various infective organisms. Inasmuch as the better the blood supply and the less exposed to trauma the tissues are, the less is the chance of an ulcer occurring, it will be obvious that ulceration is more liable to affect the elderly, especially those suffering from arteriosclerosis in its many forms, or from any obstruction to the venous return, for example, varicosity of veins or cardiac failure, and in those whose occupation exposes them to injury of the skin or to infection of the alimentary canal. It is also obvious that the dependent lower part of the leg will be more prone to suffer ulcerative processes than any other part of the body.

3. MORBID ANATOMY

Tissue changes

The tissues surrounding and beneath the raw area of the ulcer will show in greater or lesser degree the changes of inflammation with consequent oedema, which in old-standing cases has proceeded to fibrosis. Subsequent to healing, the ulcer is replaced by scar tissue, and covered by epithelium which differs from the normal surface epithelium in the absence of glands and—where present in the surrounding tissue—of hair follicles. As a result of the underlying fibrosis, there is usually slight depression of the scar, which is of lighter colour than the surrounding skin owing to avascularization.

Clinically, the appearance of any ulcer differs according to the length of time the lesion has been present, and it is customary to describe spreading, healing and callous (chronic) types of ulcer.

(1) Spreading ulcer

Inflammation

Discharge

In the spreading ulcer, the acute stage of inflammation in and around the lesion will be manifest, the edge is ragged and oedematous, the floor often shows sloughs and there is a free discharge of a sero-purulent nature (ichor) which is irritating to the surrounding epithelium, on which it often forms a dark scab covering both the ulcer and the surrounding inflamed tissues. The base of the ulcer in the acute stage shows some oedema and redness; it is

tender on pressure and causes the patient considerable pain by irritation of the nerves in the inflamed tissues.

(2) Healing ulcer

In the healing ulcer the edge of the ulcer shows the growth of thin epithelial tissue over the red, sprouting granulations covering the floor, the ulcer base calls for no special comment. At this stage there is little or no discharge from the granulating tissues, which have a glazed appearance, and this ulcer should be painless.

(3) Chronic ulcer

In many cases, especially in the lower part of the leg in elderly persons, where either the blood supply is deficient or the venous return is obstructed, there is not sufficient vitality in the tissues to overcome completely the initial infection, and in such cases a state of chronic inflammation develops in the base of the ulcer, which therefore becomes thickened and undergoes considerable fibrosis (Fig. 137). As a result of this, the granulations on the floor become pale and sparse, thus further delaying the healing of the ulcer, which assumes an unhealthy appearance, very frequently with pigmentation around the edge due to destruction of blood cells. The pigmented debris cannot be carried away owing to the poor vascularity of the part. The surrounding skin is often in a state of chronic inflammation with desquamation, small superficial ulcers and considerable serous discharge. This condition is generally described as one of varicose eczema and is a condition which, on the slightest trauma or infection, is prone to break down readily with the formation of further extensive ulcers.

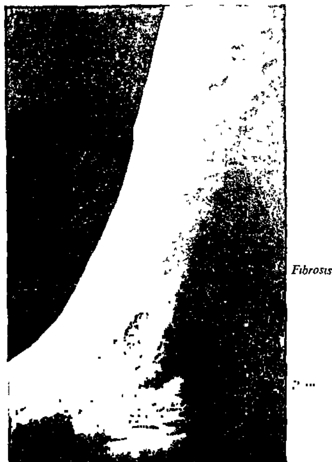


FIG. 137.—Chronic ulcer of leg below varicose veins.

Varicose eczema

The various types of chronic ulcer due to specific infective organisms are described under Differential Diagnosis (*see* p. 343).

4. CLINICAL PICTURE

Secondary infection

The clinical picture of ulceration varies considerably according not only to the causative organism but to whether secondary infection has occurred,

which it frequently does in the case of old-standing ulcers. In certain infections it may be many days or even weeks before the inflammatory process results in the formation of an ulcer, whilst in the case of malignant ulcers it is not until cells of a neoplastic tumour have infiltrated and destroyed the surface epithelium that the ulcer manifests itself in the centre of the area so infected.

It must be borne in mind that a small "ulcer" of long-standing may in fact be the external orifice of a sinus or of a fistula.

(1) Acute ulcer

Glandular involvement

The acute ulcer is always painful, the base is red, oedematous and tender, the edge is unhealthy and swollen and the floor is usually covered with sloughs and pus. The neighbouring lymph glands are frequently enlarged and tender, and may, indeed, break down to form an abscess. There are also constitutional signs of infection which are not, however, usually severe.

(2) Healing ulcer

In the healing ulcer the local inflammatory process has subsided. The tissue round the ulcer, though probably a little swollen, shows no other abnormality, the floor of the ulcer is covered with red granulation tissue, while the edge shows a thin blue line of ingrowing epithelium.

(3) Chronic ulcer

Arteriosclerosis and varicosities

The chronic ulcer, of which the varicose ulcer is a typical example, is the form most frequently seen in medical practice, because it is usually only when an ulcer is not healing that the patient consults his medical attendant. In such cases there is usually poor blood supply to the area, due to either arteriosclerosis or varicosity of the veins leading from the part. Owing to its dependent position and liability to trauma, the lower part of the leg, most commonly on the inner side of the subcutaneous surface of the tibia, is the usual site of a chronic varicose ulcer. The base of the ulcer is usually thickened, indurated and fibrosed, and often adheres to the underlying structures and bone. The skin around is unhealthy, desquamating and may show considerable pigmentation. The edge of the ulcer shows little or no inclination to epithelial tissue formation, while the floor is pallid, smooth, fibrotic and may even show areas which in appearance are similar to cartilage. There may be signs of inflammation accompanied with pain, and in such cases the neighbouring lymph glands will be tender as well as enlarged and matted.

Glandular involvement



FIG. 138.—Carcinomatous ulcer supervening on a chronic varicose ulcer of long-standing.

(4) Malignant ulcer

Malignant ulceration (Fig. 138) only occurs as a result of molecular death from the infiltration of

tissues by a tumour leading to destruction of the tissue beneath the epithelium.

The process of such an ulcer, therefore, consists of an infiltrating and usually hard mass of malignant tissue which will be invading, and fixed to, the deeper structures. The edges will be thick, elevated and often everted, from fibrosis amongst the malignant tissue cells, while the floor of the ulcer *Fibrosis* consists of sloughing and necrotic malignant tissue which may or may not be vascular and may bleed easily according to the nature of the neoplasm. Enlargement of the neighbouring lymph glands may be due to infection or, in the later stages, to metastases. As a result of chronic ulceration and infection, well-marked anaemia is frequently present, both in chronic and *Anaemia* malignant ulcers.

Malignant changes may occur in any chronic ulcer of long-standing These usually take place in the epithelium at the ulcer edge, when a typical malignant ulcer of a carcinomatous type results Very rarely, however, such malignant metamorphoses occur in the fibrosed vascular tissue of the ulcer floor, when a fibrosarcoma is formed.

5. SPECIAL INVESTIGATIONS

Whenever there is doubt as to the nature of an ulcer on clinical examination, it is wise either to excise the entire ulcer, if small, or to remove a portion of the edge in order to submit it to microscopical examination. Cultures can *Biopsy* be taken from the ulcer floor, but these are usually of little value because considerable septic contamination is nearly always present. However, in certain cases cultures yield valuable bacteriological results when a smear is stained and examined under the microscope. Blood and serum reactions *Blood and serum tests* should be taken as a routine in any cases suspected of being syphilitic or a result of lymphogranuloma, whilst in other cases appropriate tests of this nature must be carried out.



FIG. 139.—Bedsore (trophic ulcer) over the exposed great trochanter of the femur.

6. DIFFERENTIAL DIAGNOSIS

Differential diagnosis lies between the different types of ulcer which occur in various infections.

(1) Acute ulcer

Acute septic ulcer has been described already.

(a) Impetigo

Impetigo is a diffuse streptococcal infection

Streptococcal infection

with incrustations well marked, resulting from streptococcal infection of the cuticle, and is usually seen on the face and exposed parts of the skin.

(*b*) *Trophic ulcer*

Nerve lesions

Trophic ulcer occurs rapidly as a result of central or peripheral nerve lesions of a partial nature. The surrounding skin is usually atrophic, the ulcer may spread rapidly and deeply as in bedsores (Fig. 139) or, if on the cornea, may lead to perforation of the globe.

(*c*) *Acute subcutaneous infection with gangrene*

A result of acute infection in the subcutaneous tissue with gangrene of the overlying skin, for example, ulceration over a carbuncle, may resemble an acute ulcer.



Fig. 140.—Multiple soft chancres.

Cellulitis and erysipelas

Spreading subcutaneous gangrene around an infected surgical wound with its deep undermined edges and large extensive sloughs is not commonly met with (*See* Post-operative Gangrene, Vol. 7, p. 108.) Similar areas may occur in intense cellulitis or erysipelas; rarely cancrum oris and noma vulvae are met with.

(*d*) *Venereal infection*

Soft chancre (chancroid) (Fig. 140) appears rapidly, discharges freely and shows inguinal glands matted, tender and suppurating or ulcerating.

(2) Chronic ulcer

(*a*) *Varicose ulcer*

A varicose ulcer may be present on the inner and lower part of the limb; in old-standing cases the limb may be entirely surrounded by the ulcer. Varicose veins with valvular incompetence are always present, the surrounding skin is oedematous, eczematous and often pigmented and may be painful. The floor of the ulcer is covered with small, scanty granulations (see Fig. 137).

(*b*) *Trophic ulcer*

Involvement of joints

A perforating ulcer on the sole of the foot, surrounded with cornified epithelium, may penetrate and infect the neighbouring joints. This condition is usually seen in tabes dorsalis but may occur in any nerve lesion (*see* Perforating Ulcer of the Foot, Vol. 6, p. 540).

Leprosy

Similar ulcers, often accompanied by extensive gangrene, occur in leprosy (*see* Leprosy, Vol. 5, p. 405)

(c) *Venereal infection*

(i) *Syphilitic ulcer.*—The Wassermann reaction is positive in the second and third stages and also in the late primary stage of syphilis. In the primary stage an indurated chancre may appear on the genitalia (Fig. 141). The neighbouring *Primary stage*

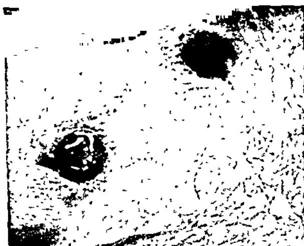


FIG. 141.—Two coexistant hard chancres. (A rare phenomenon)



FIG. 142.—Chancre of lip, with secondary rash on face. Note the swollen neck from glandular enlargement.



FIG 143.—Gummatous ulcers.

lymph glands are enlarged, discrete, mobile, and painful. An extra-genital chancre is not indurated, but the neighbouring glands are similarly enlarged (Fig. 142).

Superficial ulcers which, in the secondary stage of syphilis, appear around *Secondary stage*

the mouth, fauces, anus and vulva, spread rapidly, and are coated with shiny mucus (snail-track ulcer). Other secondary stigmata are frequently present. Condylomas in moist parts are hypertrophied masses of granulations.

Tertiary stage

In the tertiary stage a gummatous ulcer may occur in any situation, presenting as a deep, circular ulcer, the floor of which is covered with wash-leather slough which on removal shows bright-red granulation tissue. Several ulcers may coalesce to form a crenated ulcer which tends to spread serpiginously (Fig. 143).

(ii) *Framboesia.*—Framboesia (yaws) occurs in the tropics. Multiple ulcers, often with much prominent granulation tissue, are met with all over the body (*see* Yaws).

(iii) *Lymphogranuloma inguinale and granuloma pudenda.*—The ulcers resulting from these conditions occur in the inguinal region and the rectum, often causing extensive scarring and stricture, and are seen more frequently in coloured people. The reaction to the Frei test is positive (*see* Lymphogranuloma Inguinale, Vol. 5, p. 487).

(d) Bejel

Bejel is a disease much resembling syphilis and yaws and is seen among Arabs in the Middle East.

Wassermann reaction

The Wassermann reaction is weakly positive in these three last-mentioned diseases, and also in leprosy but usually strongly positive in syphilis.

(e) Tuberculosis

The ulcer in tuberculosis is shallow, with undermined edges and exuberant pale granulation tissue, with the surrounding skin often blue and discoloured. It is frequently situated in the centre of a mass of infected lymph glands.

Lupus erythematosus

(i) *Lupus vulgaris.*—This condition gives rise to superficial ulceration and scarring often around the mouth and nose; it may be mistaken for lupus erythematosus, which has a "butterfly" distribution over nose and cheek. "Apple-jelly" nodules of lupus vulgaris are typical; hypertrophic verruca necrogenica may appear after injury to the fingers or forearm (*see* Lupus Vulgaris, Vol. 5, p. 476).

(ii) *Bazin's ulcer.*—Bazin's ulcer occurs on the back of the calves; it is indurated, nodular, usually symmetrical, and may be painful.

(f) Actinomycosis

Multiple small sinuses present in a dense indurated mass; sulphur granules may be found in the pus. Madura foot is similar in appearance.

(g) Diphtheritic ulcer

This ulcer appears with a black slough on the surface, usually around the perineum and groin, but may be elsewhere. It is a very callous ulcer. Bacteria are present in scrapings. It mostly occurs in tropical countries and heals rapidly when treated with the specific serum.

(h) Fungus infections

Fungoid sporotrichosis may be due to tinea (and may be contagious from cattle), to blastomyces, or to torula; the fungus is always found in scrapings.

(i) *Protozoal infection*

(i) *Delhi boil.*—In Delhi boil (desert sore) Leishman-Donovan bodies can be demonstrated. *Leishman-Donovan bodies*

(ii) *Amoebic ulcer.*—This condition presents as sloughing ulcers around the perineum, or as multiple and painless anal fissures.

(iii) *Bilharziasis.*—Bilharzial ulcers show redundant granulations in the rectum and perineum and rarely on the skin in the neighbourhood. The condition is usually met with in Egypt, the Transvaal and Iraq.

(j) *X-rays and radium*

Dermatitis, ulceration and carcinoma may result after exposure to x-rays or to radium.

(k) *Artefact*

Artefacts usually occur on the lower abdomen and thighs in psychoneurosis. *Psychoneurosis*

(l) *Gout*

Chronic ulcers appear around the joints of elderly patients, usually men, with evidence of gout; there are white calcareous deposits of urate on the floor and in the base.

(3) Malignant ulcer

(a) *Carcinoma*

A carcinomatous ulcer has raised, everted edges with induration of the base and surrounding tissue from infiltration; the neighbouring glands are usually affected. The carcinoma is fixed, hard and matted. It is a condition which is occupational in shale oil and tar works, and must then be notified under Home Office order. Such ulcers may occur secondarily on part or the whole of any chronic ulcer (*see* Fig. 138) *Occupational*

(b) *Rodent ulcer*

A rodent ulcer usually occurs on the face, rarely elsewhere; it starts as a papule, spreads superficially and deeply, and shows healing in spots with little induration The glands are not involved. It may be mistaken for infective ulceration caught from sheep (orf), which usually appears on a shepherd's face. A facial desert sore, a syphilitic ecthyma or lupus vulgaris may cause difficulty, but a biopsy of the edge will clear up the diagnosis. *Orf*

7. TREATMENT

In all cases of ulceration, sulphonamides and penicillin should be given, as they deal with any infection and tend to hasten healing Administration of these substances locally in the form of pastes and powders is, on the whole, unsatisfactory.

(1) Acute ulcer

In the infective stage, rest and elevation of the affected part and the application of hypertonic saline dressings are recommended. As the inflammation settles down, dressings containing free chlorine such as Milton or eusol

Removal of sloughs

should be employed to remove sloughs if present, but must be stopped immediately these have disappeared. Then, if the ulcer is clean, epithelialization should be assisted by some zinc lotion such as the following.

Zinci sulphas – – – –	10 grains
Alumen – – – – –	20 grains
Glycerinum – – – –	7 ounces
Aqua ad – – – –	1 pint

In the treatment of trophic ulcer, spirit or thymol should be employed; wet dressings must be avoided. The part should be elevated and rested, if necessary with splints. If the ulcer is very large, a "postage-stamp" skin graft should be employed as soon as the sloughs have cleared, with the adjunct of adequate chemotherapy.

Skin graft

(2) Chronic ulcer

Stimulation

When chronic ulcers result from a specific disease, appropriate means must be employed to treat this disease. The ulcer needs stimulation, and for this purpose an antiseptic dressing must be employed to clean, after which a stimulating dressing of zinc and glycerin is appropriate. Skin grafting is unlikely to prove of value unless the blood supply is sufficient to support good granulation tissue and here a judicious lumbar sympathectomy is useful in some cases. Local support to the region is necessary if oedema is present and here plaster of Paris, Elastoplast and Unna's dressings are valuable and should not be disturbed more frequently than is absolutely necessary. For artefact ulcer, rigid protection to prevent interference is required until healing is sound. In varicose ulcer the veins must be dealt with surgically.

Local support

Artefact ulcer

(3) Malignant ulcer

Excision of the ulcer, with at least 1 inch of the surrounding tissue, and removal of the neighbouring lymph glands are essential in the treatment of malignant ulcers Radiotherapy offers a less satisfactory method of treatment in most cases, although it is usually advocated for rodent ulcers. In extensive cases the amputation of a limb or drastic surgery may be necessary.

Radiotherapy

8. INDICATIONS FOR SURGICAL INTERVENTION

Skin grafts

Skin grafting may be indicated in healing acute ulcers of large size. It should be undertaken early to prevent scarring and should be of the "postage-stamp" variety to allow escape of exudate between the grafts. Skin grafting may be necessary in covering the granulating surface of chronic ulcers, but is unlikely to succeed unless the blood supply is sufficient to produce adequate granulation on the ulcer floor.

Lumbar sympathectomy

Amputation

Lumbar sympathectomy and whole-thickness skin grafts following excision of the ulcer have proved useful in certain skilled hands in securing permanent healing of very intractable ulcers of the varicose type. Rarely, amputation may be necessary in very extensive or painful chronic ulcers, and in all cases where malignancy has supervened.

Carcinoma

Malignant ulceration of the carcinomatous type is an indication for free

excision plus removal of the nearer lymphatic glands. Skin grafting may be necessary subsequently.

In extensive carcinomatous ulceration and in sarcoma amputation may be called for.

9. PROGNOSIS

In acute ulcer the prognosis is good, except in trophic ulcer, if treatment is promptly and efficiently carried out.

In chronic ulcer, the prognosis is always doubtful, and relapses occur frequently in varicose ulcer of long standing. In other types, treatment of the disease combined with adequate local treatment is often successful in securing healing, but scarring is bound to result.

Malignant ulcers have naturally a poor prognosis. Recurrence is not common in early treated rodent ulcer, which has the best prognosis of the malignant ulcers.

I must acknowledge my indebtedness to many colleagues at St. Thomas's Hospital for help with the illustrations of this article.

[References to other titles are given under Ulcers and Ulceration in the Index Volume.]

UMBILICUS–DISEASES OF

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1. NEONATAL PYOGENIC INFECTIONS

[illegible] of the body [illegible]
tion. The care of the umbilical cord is vital to the well being of the [illegible] mild infection may pass unnoticed. *Pyogenic infection, usually by the staphylococcus,* may come to light clinically in one of several ways.

(1) Granuloma

Antiseptic powder

The site of the cord may remain moist; this is the commonest manifestation of infection and is dealt with by applications of antiseptic powder: a granuloma may form.

(2) Cellulitis

There may be a spreading cellulitis *which calls for more radical means of treatment* by local applications and by systemic chemotherapy.

(3) Abscess

The infection may travel up the umbilical vein along the ligamentum teres and subsequently an abscess develops in the epigastrium. This abscess may not be evident until it has reached a considerable size because it is deep to the linea alba. Neonatal sepsis is sometimes met by very little resistance on the part of the baby and therefore there may be no fever. The presence of a tender tumour in the epigastrium, especially if there is redness of the overlying skin, should always give rise to suspicion of an abscess arising in the ligamentum teres in a new-born child, and the symptoms may be simply digestive disturbance. Such a tumour, with the associated vomiting and loss of weight, may be mis-diagnosed as a pyloric hypertrophy. Infection may travel down the obliterated umbilical arteries and an abscess may develop in either iliac fossa, simulating on the right an appendix abscess. Pressure on it may squeeze pus from the umbilicus. The treatment of the abdominal wall abscesses is aspiration and instillations of penicillin; if this is unsuccessful, incision and drainage is necessary.

Absence of fever

Symptoms

Mis-diagnosis

Penicillin treatment

(4) Jaundice

If the infection proceeds further, hepatitis occurs and the subsequent jaundice has to be distinguished from neonatal jaundice due to other causes. A general surgeon must acquaint himself with the points of differential diagnosis, because he is often called in to express an opinion on a baby whose jaundice has persisted in time and depth beyond the physiological limit. The jaundice is most likely to be confused with that due to maternal–foetal Rhesus incompatibility.

Hepatitis

Rhesus incompatibility

(5) Osteitis

A surgeon may first see the baby on account of osteitis affecting one or several sites. He must remember that this is a manifestation of bacteraemia and the commonest primary infection in babies occurs at the umbilicus. Treatment of infection metastatic from the umbilicus in the new-born must include, at the earliest possible moment, administration of penicillin. The consequence of neglect or delay at this stage may be extremely serious, but with early treatment many limbs are spared even impaired function. If the hip joint is involved the femoral capital epiphysis is invariably destroyed.

Bacteraemia

Early administration of penicillin

2. FUNGUS AND PARASITIC INFECTIONS

At any age the umbilicus, commonly involved in generalized skin disease, may, however, be the only site of infection, and because of this the nature of the infection may be missed Scabies and ringworm infections (epidermophyton, tinea, trichophyton) are the most common. All these produce macerated pustular lesions in the umbilicus and the surrounding oedema may vary.

Usually, in scabies, lesions can be found elsewhere on the body: treatment with benzyl benzoate is rapidly curative.

Scabies

Fungus infection is difficult to eradicate if the umbilicus is deep. If instillation of weak solution of iodine on two or three occasions fails to cure the infection, ionization with copper is specific and usually only one treatment is required. The umbilicus is packed with cotton-wool soaked with 2 per cent

Fungus infection

copper sulphate solution; embedded in the cotton-wool is a small metal electrode connected to the anode of a galvanic circuit; *a current of 10 milliamperes is passed for 10–15 minutes.*

Pediculosis infestation

Pediculosis infestation of the umbilicus occurs and may remain if treatment for lice infection elsewhere on the body has been inadequate.

All these lesions are characterized by irritation, excoriation and oedema of the umbilical cutaneous ring.

3. VITELLO-INTESTINAL REMNANTS

(1) Faecal fistula

Discharge

The umbilicus may fail to dry up after the separation of the cord or may become moist later in life. The amount of discharge may vary from day to day. The discharge may arise from a simple infection of the umbilical skin; if this is the case the stump of the cord has usually been inflamed and oedematous. If there is little or no surrounding inflammation and the usual treatment for infection has failed, then a fistula must be suspected. The umbilicus can often be best examined with an illuminated aural speculum. Radiology may help to outline the sinus and for this purpose Lipiodol is the best medium to inject; this can be done with a small cannula, and lateral and postero-anterior skiagrams should be taken. A cystogram may help also by showing the relation of the apex of the bladder to such a fistula. An umbilical fistula may arise by persistence of either the vitello-intestinal duct or of a connexion with the bladder by way of the urachus. Since all such congenital remnants which communicate with the umbilicus have a lining of epithelium, they will not heal spontaneously. A more copious discharge occurs from the intestinal remnants. Reference should be made to the section on Meckel's diverticulum (Vol. 3, p. 257).

Aural speculum

Umbilical fistula

(2) Simple tumour

Morphologically, the vitello-intestinal remnants are cylindrical, although polypi may occur from heterotopic mucous membrane remnants at the umbilicus (*see* Heterotopia, Vol 4, p. 477). Occasionally, the vitello-intestinal remnant may be merely a patch of mucous membrane with the pancreatic tissue in it, and such a residue can be distinguished from an infective granuloma at the umbilicus only by biopsy: this is rarely justified and the application of a silver nitrate stick to something which appears to be a granuloma will cure it unless there is a sinus.

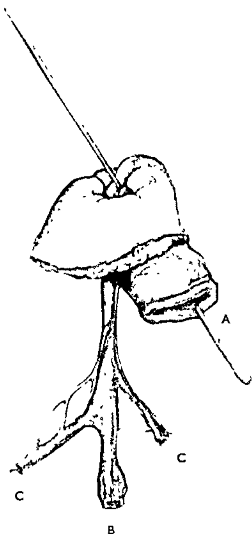
Biopsy

Silver nitrate stick

(3) Prolapsed diverticulum

The tumour may be too big to cauterize and may be pedunculated; a piece of thread is then tied round the base; the mucosal polypus drops off in a few days, and if an undetected fistula should be present, the prolapse will recur and the final treatment is radical excision. An elliptical excision of the whole of the umbilicus is performed and the edges of the excised skin are closed over the raw umbilicus before the peritoneum is opened, in the same way as the anus is covered over by the surrounding skin before a rectal excision.

Excision of the umbilicus



Umbilicus excised from a baby, 8 weeks old, showing (A) patent Meckel's diverticulum, (B) urachus, and (C) obliterated umbilical arteries. (*Author's case*)

PLATE IV

After the peritoneum has been opened any communicating band or diverticulum from the ileum must be excised, and the abdominal wall is closed in the usual manner. In a baby, during the operation, the surgeon will notice the prominent obliterated umbilical arteries, and the urachus (normally represented by the median umbilical ligament) may be patent from the bladder up to the umbilicus without actually opening on to the surface. Care must be taken, therefore, to close and oversew this urachal stump and to make certain that it is placed outside the peritoneum. *Urachal stump*

Gross ileo-umbilical fistula is seldom seen but may become evident after a non-fistulous "polypus" has been excised or tied off. The coincidence of urachal and vitello-intestinal fistula is rare. Barrington-Ward (1937) cites only 3 such cases. In the case illustrated in Plate IV the baby was four weeks old when a granuloma or polypus less than 1 centimetre in diameter was tied off. It sloughed partly but, owing to its vascularity, grafted itself on again as fast as the thread cut through. At 8 weeks, while on the operation table, the baby passed a normal-sized soft stool through the umbilicus. The intraperitoneal diverticulum was 4 centimetres long. The urachus was patent, although no urinary leak at the umbilicus had been detected.

4. ALLANTOIC (URACHAL) REMNANTS

The tubular connexion between the umbilicus and the fully formed bladder is represented in the mature foetus by the median umbilical ligament. This ligament is not, however, entirely fibrous and it has been shown conclusively that in the normal urachal remnant there may be found rods of cells representing foetal epithelium. From these cells there may arise cysts or carcinomas. The urachus may persist therefore as (i) the normal ligament, (ii) a tube opening at the umbilicus and blind below, (iii) as a median sub-umbilical cyst in the abdominal wall, or (iv) as a diverticulum from the apex of the bladder.

Damage to the latter form, during operation on the umbilicus or at the mid-line of the abdomen, may result in the development of a urinary fistula not previously present.

A blind external fistula produces a little umbilical discharge which is clear and sticky, but free from urine and faecal contamination. *Blind external fistula* A urachal cyst is often tender and rarely comes to notice clinically until its contents become infected. *Urachal cyst* It can be moved from side to side but not vertically. A communicating sinus discharges urine, *Communicating sinus* a cystogram may give valuable information, or a simple intravenous injection of methylene blue (5 millitres of a 1 per cent solution for a child aged one year) may result in staining at the umbilicus and will indicate the origin of the discharge; care must be taken, of course, that urine does not reach the umbilical dressing from the diaper; the dressing should be sealed with waterproof strapping while the test is in progress.

Urachal remnants should be excised and it is not necessary to remove the umbilicus The wound should always be drained and an indwelling urethral catheter left in position for 48 hours. *Indwelling catheter* Operation is never urgent and need not therefore be undertaken in tiny babies.

It should be remembered that urinary stones may form along the course of such umbilical urinary fistulae. *Urinary stones*

5. TUMOURS OF THE UMBILICUS

(1) Simple tumours

(a) Moist

As has been already described, a moist tumour may be either an *infective* granuloma or a heterotopic mucosal polypus. Malignant deposits may, of course, ulcerate.

(b) Dry

Fibroma, lipoma and naevus occur at the umbilicus. An irreducible umbilical epiplocele may be indistinguishable from a fibroma.

(2) Malignant tumours

Enteroteratomas sometimes become malignant. Carcinoma of the urachal remnants is extremely rare. Willis (1948) *refers to two papers on the subject* and describes the growths as mucus-secreting carcinomas. They have to be distinguished *from a primary midline fibrosarcoma or a metastasis from* an abdominal primary growth. The spread is downwards along the course of *the obliterated umbilical vessels to the external iliac glands and the extra*-peritoneal pelvic space. Nothing is known of treatment except excision of an *early primary growth.*

Mucus-secreting carcinomas

The umbilicus may be the first site of secondary growth to be found clinically. *If a tiny umbilical hernia is present a peritoneal deposit may arise, but usually* the spread is lymphatic, or direct spread may come from primary growth in *the pelvis or epigastrium. In such cases other evidence of advanced malignant* disease is usually at hand. Endometrioma provides a characteristic syndrome *of painful umbilical swelling noticed during menstruation.* Unless endometriosis is known to be extensive elsewhere, such a solitary deposit should be removed.

Endometrioma

6. EXOMPHALOS

Exomphalos is a persistence of the developmental ventral gap in the abdominal wall, and amounts to the presence of a large umbilical hernia containing intestine and very often a portion of liver (Fig 144). The hernial sac is, however, thin and moist and is not covered by skin. This absence of skin distinguishes exomphalos from true umbilical hernia, however big the latter may be. There is no doubt that some of the very large umbilical hernias present at birth are really exomphalic but the skin has grown over the gap before delivery. There is a very great potential for spontaneous epithelialization even after birth. Fig. 145 shows the spontaneous cure of an exomphalos and the child has now a simple umbilical hernia with a ring about 2·5 centimetres in diameter. The original condition was like that shown in Fig. 144. Intestinal obstruction may precipitate the necessity for operation (Fig. 146).

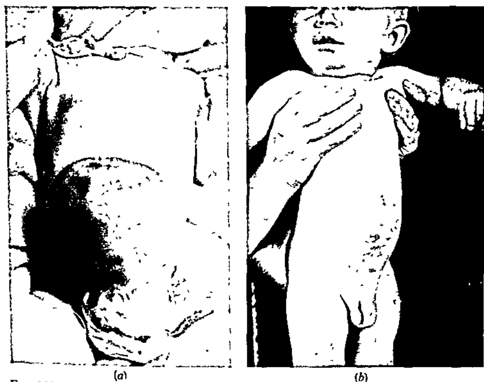
Chance of survival

It is commonly thought that without radical surgery to replace the viscera and to close the abdominal wall within the first few hours of life, *the child* has little chance of survival. This is not always true however; if the amount of extra-abdominal bowel is not great and *if the sac does not contain part of* the liver, operation is less urgent. Although it may appear at first that the patient's life is entirely dependent on *rapid and skilful surgery, the surgeon*

must bear in mind that he cannot save the child's life unless he has at his disposal absolutely first-class baby-nursing and the necessary equipment for transfusion for infants, and an oxygen box. It is also essential that the anaesthetist should be experienced in the administration of anaesthetics to the new-born. It may, therefore, be wiser for the surgeon to move the baby to a centre where these facilities exist rather than to risk life by his own unaided skill and boldness. He must also remember that a spontaneous cure is possible. *If the exomphalos is left alone a dressing of penicillin and* sulphanilamide cream is used. *Spontaneous cure*

Operative treatment

The baby should be attached to a cruciform splint (*see* Pyloric Stenosis of Infants, Vol. 7, p. 246) and intravenous infusion should be set up because the child will almost certainly require restorative measures. The edges of the *Cruciform splint*



(*a*) (*b*)

Fig 144 —(*a*) Gross exomphalos The patient was operated on successfully on the first day of life. If the umbilical cord is at the lower end, the sac must contain liver, as in this case (*b*) The same patient, 1 year later. (*By courtesy of the Hospital for Sick Children, London*)

gap are excised and the contents reduced inside the abdomen and covered with a warm pack. The umbilical vessels must be transfixed and tied with chromic catgut and their stumps buried. By dissecting broadly, the peritoneum may be freed sufficiently to close the gap. The muscle and skin are approximated by through-and-through sutures in one layer If neither peritoneum nor muscle can be closed the skin should be freed and sutured even if counter incisions are required to allow closure. Two or three weeks later the wound may be reopened and it will be found that the muscles and peritoneum can now be closed in layers In all cases the wound should be kept dry by application of *Sutures*

sulphanilamide and penicillin powder and the sutures left in place for 10 days. Doses of 100 milligrams of ascorbic acid must be given daily and it may be necessary to relieve distension by an indwelling gastric tube.



FIG 145.—Girl aged 4½ years. Exomphalos the size of a large orange at birth. No operation took place, there was spontaneous cure, leaving a small umbilical hernia (*By courtesy of the Hospital for Sick Children, London*)



FIG 146—Minor exomphalos, child was admitted to hospital at 2 days old and died of intestinal obstruction. (*By courtesy of the Hospital for Sick Children, London*)

7. UMBILICAL HERNIA

Need for support

Hernia at the umbilicus is almost alw... ital but may remain un-
noticed or untreated until it enlarges ... decades of life, when the
abdominal muscles are beginning to ... infant the hernia may
be noticed as soon as the cord has ... if unsu ... may en-
large rapidly, ... 4 or 5 inches in ... i ... of a very
large herni... is for the ... by ... of

the rectus muscles. The majority of these hernias come forward through the centre of the umbilicus, but occasionally there is an elliptical opening immediately above or below the umbilicus. Very rarely in the child does the contained omentum become adherent.

Symptoms Symptoms are very common and mainly consist in attacks of abdominal pain associated with some form of dyspepsia. In the presence of such symptoms an umbilical hernia should never be ignored.

Treatment

It is quite unnecessary to operate on an umbilical hernia until the child has reached the stage of standing. Until this point, the abdominal musculature has not developed adequately and a diminution in the size of the hernia can, therefore, be expected. After the age of 2 years, a "cure" by strapping or by a truss is extremely unlikely, and unless the hernial ring is smaller than 1 centimetre in diameter an operation should be advised

(a) *Strapping*

A simple small hernia up to 2 centimetres can be protected adequately after reduction by the cruciform application of 2 strips of 1-inch adhesive zinc oxide plaster, the abdominal wall being bunched up on either side in two vertical ridges which are closed over the hernia. Under no circumstances should elastic adhesive strapping be used, neither should any pad, penny or button be inserted under the strapping. Any such pad tends to keep the muscles apart and therefore allows the hernial ring to remain stretched, whereas the method of strapping described above is designed to bring the skin and subcutaneous tissues together over the hernia, thus preventing its protrusion rather than pressing into the hole. Such support must be kept on continuously and this will mean that the child may not be bathed for several months. One of the causes of failure is that, unless previously warned, a mother may leave the strapping off for a night, or until the next hospital visit. It is essential that the mother should be instructed in the method of strapping and she herself should renew it when it becomes necessary. *Cause of failure of treatment* For a large hernia one strip of 3-inch-wide zinc oxide strapping should be applied with the midline depressed between the approximated rectus muscles and skin folds. Rubber belts of any sort are to be condemned and the use of a subcutaneous purse-string suture of silk or catgut is mentioned only to be condemned as uncertain and dangerous. *Trusses condemned* Fig. 147 illustrates the effectiveness of very simple strapping started at the age of 1 month.

(b) *Operation*

If the child has reached the age of 2 years and even a small hernia persists, operation is advised (Fig. 148). Under general anaesthesia, a simple dissection and gap closure is performed. This may be described in stages. *First stage* (i) The umbilical skin is held up towards the head with a small tenaculum forceps; an *Incision* incision 2·5 centimetres long is made transversely at the junction of the umbilicus with the abdominal skin at its lower periphery. The skin is freed from fascia all round the umbilicus. *Second stage* (ii) It will be seen that the fibrous rectus sheaths fuse and form a weak fascial cone going right into the umbilical apex. In this way an umbilical hernia differs from other forms of hernia. This

fibrous cone is next incised *transversely at its lower base*. This exposes the tissue-paper-like peritoneum. (iii) Using a pair of miniature curved blunt-pointed scissors the operator now separates very gently the peritoneal cone from the fibrous cone all the way round. At its junction with the skin it is clipped, cut, and a ligature is tied round it; any omental tag within it must be freed first; the peritoneal stump is pushed inwards gently. Two or three mattress *stitches of number 60 linen thread* are then used to approximate the upper base of the fibrous cone to the lower cut edge of linea alba. The umbilical edge of the lower fibrous cone base is sewn down to the rectus sheath; this

Third stage



(*a*) (*b*)

FIG 147.—Large umbilical hernia; (*a*) before and (*b*) after strapping. (*Author's case*)

amounts really to the Mayo operation. Two number 000 catgut sutures should approximate the subcutaneous fat to maintain the umbilical contour. A subcuticular continuous nylon stitch closes the skin and it is tied over a small gauze dressing dipped in compound iodoform paint (Whitehead's varnish). A patch of elastic strapping with a small aeration puncture cut in its centre is then applied. Small children need not remain in hospital or even in bed. The stitch is removed on the eighth day. For this to be painless the elastic strapping is lifted gently at the side, taking with it the dressing and exposing the tightened subcuticular suture, which is then cut. The whole dressing is swept away with the stitch and the child need not be hurt. To use interrupted stitches at the umbilicus is courting aggravation and is an unnecessary inconvenience to the child.

Gauze dressing

Removal of stitch

In the absence of any gross abdominal pathology such as hepatosplenomegaly or ascites, umbilical hernia in children does not recur after operation.

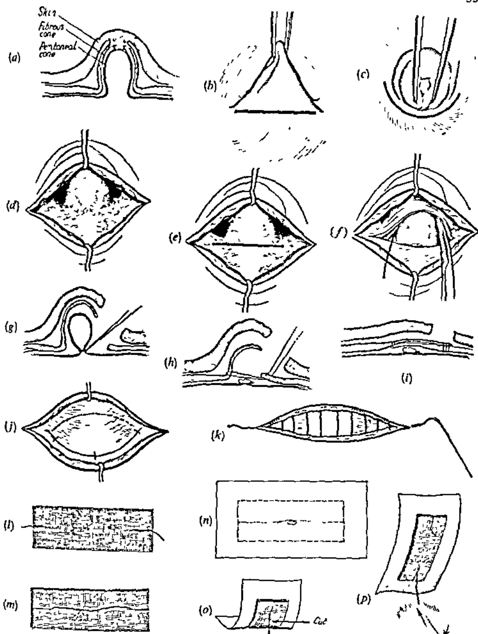


FIG 148 — [illegible]
u[illegible]
b[illegible]
cr[illegible]
(*f*) the peritoneal cone is blunt dissected with ophthalmic curved scissors and detached from its [illegible]

[illegible] layers of thread mattress sutures, (*k*) the skin is closed by a continuous subcuticular nylon suture, (*l*) the wound is sealed with Pigmentum Iodoformi Compositum (*B P C*) Whitehead's varnish) and thin gauze with a slot in each end; (*m*) the single suture is tied over the dressing pad; (*n*) the whole is covered by a 6-inch strip of elastic adhesive plaster *not* put on the stretch, a small vent hole is cut in the plaster; (*o*) on the eighth day one end of the plaster is peeled up, carrying with it the gauze pad and thus exposing the nylon where it emerges from the skin, the stitch is then cut; (*p*) the whole dressing and single stitch are quickly removed in one manoeuvre.

8. THE UMBILICUS AS A SIGNPOST

The umbilicus, situated as it is, acts as an indicator in various ways.

Paralysis

Paralysis (anterior poliomyelitis, or post-diphtheritic paralysis) may be unequal when the abdominal muscles are affected and such inequality can be demonstrated by deviation of the umbilicus when the oblique muscles contract. Indeed, this deviation may be the first physical sign of paralysis and should be watched for in cases of diphtheria and suspected poliomyelitis.

Ascites

In ascites, the umbilicus becomes everted, but this can only occur if there is a hernia at the umbilicus.

Lordotic diseases

In the "pot-belly" lordotic diseases, such as gargoylism or rickets, a large umbilical hernia may be the lesion which first brings the child to the specialist

Portal hypertension

In portal hypertension, portal-systemic venous anastomotic channels may open up around the umbilicus, giving rise to the caput medusae.

Reference has already been made to affection of the umbilicus in parasitic infections, malignant disease and endometriosis.

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[References to other titles are given under Umbilicus—Diseases of, in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 12, p. 352.]

URAEMIA

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1. DEFINITION

334.] Uraemia is a clinical condition due to a failure of the mechanisms which normally maintain the constancy of the physical and chemical properties of the body fluids, and in which, as a result of renal derangement, waste products of metabolism are accumulated. *Failure of mechanisms*

2. AETIOLOGY

The causes of uraemia are numerous but it is unnecessary to describe them in full. Those most commonly encountered by the surgeon are severe trauma, crushing injuries, major operations, haematemesis, intestinal obstruction, incompatible blood transfusions, and infections of the genito-urinary tract, as well as sulphonamide and streptomycin therapy.

3. PATHOLOGY

(1) Macroscopic findings

The kidney is increased in weight, the capsule is under tension, and when cut the surface of the kidney is everted, and the cortex bulging and pale. The sectioned surface has a yellow granular sheen and, as a result, the *Appearance of kidney*

pyramids and medulla stand out in contrast. In crush anuria and after incompatible blood transfusions, brick-red casts can be seen in the pyramids and collecting tubules. When uraemia is due to sulphonamide therapy crystals may be seen pouting from the pyramids or in the terminal part of the tubules.

(2) Microscopic findings

If the nephron be traced through its course, it is found that the glomeruli usually show little or no change. The glomerular spaces are filled with an albuminous deposit which is most marked round the periphery and is adherent to Bowman's capsule. The cells of the first convoluted tubule show

Albuminous deposit

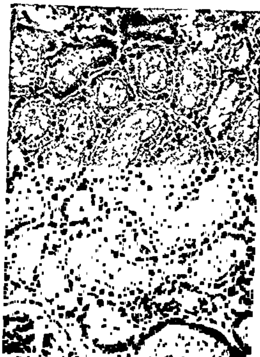


FIG. 149.—The cortical area showing albuminous eosinophilic fluid lying in the lumen of the convoluted tubules showing widespread damage to the nephron (haematoxylin and eosin × 145). (*By courtesy of J. Path. Bact.*)



FIG. 150.—Section of the medulla showing various types of cast within the loops of Henle, together with interstitial oedema and congestion (Mallory × 145). (*By courtesy of J. Path. Bact.*)

an early degenerative change and their cytoplasm stains irregularly; the nuclei are pyknotic and there is eosinophilic catarrh within the lumen (Fig. 149). The most marked damage is found in the loops of Henle, and for that reason this form of uraemia has been named by Lucke (1946) "lower nephron nephrosis". Degeneration of epithelium in this area is frequently patchy and the tubule is sometimes so distorted that it is impossible to tell whether it is of the ascending or descending type.

Tubular degeneration

The presence of casts is by no means constant but when present two types are commonly seen those which are composed largely of protein and others which are of pigment origin (Fig. 150) The casts tend to form around particulate matter such as degenerate epithelial cells or crystals of a sulphonamide. The epithelium splits up and becomes adherent to the outer surface. Occasionally the whole of the epithelium takes on a concertina-like appearance, which is known as "plication" and is most commonly seen in the

Types of casts

Plication

collecting tubules (Fig. 151). The ascending convoluted tubule in a well-marked case shows a severe degenerative change with patchy desquamation of the epithelium and widespread cast formation. Occasionally casts form as a hollow cylinder in which the protein is arranged peripherally, close to the degenerate epithelium.

The interstitial tissues are oedematous, and in places localized areas of histiocytic and polymorphic infiltration can be seen. The medulla shows marked congestion, and in places areas of haemorrhage. The most characteristic features of the syndrome are the rupture of tubules into veins, and the occurrence of venous thrombi (Fig. 152). These ruptures are surrounded by zones of infiltration and haemorrhage. In some cases localized areas of eosinophilic infiltration are also seen, suggesting an allergic origin.

Oedematous tissues

Venous thrombi



FIG. 151.—Plication of the desquamated epithelium lying in a collecting tubule. (*By courtesy of J. Path. Bact.*)



FIG 152.—Two tubules are seen close to the boundary zone about to rupture into venous space showing degeneration of the tubule basement membrane as well as the epithelium The lower has an antemortem clot adhering to its projecting surface (Mallory × 65) (*By courtesy of J. Path. Bact.*)

The only histological finding elsewhere is necrosis of the central portion of liver lobules.

4. CLINICAL RECOGNITION

It is important to recognize, prevent, and treat the condition at the earliest possible moment. Usually the earliest sign is anorexia, accompanied by hiccup, and followed within a few days by copious and effortless vomiting. In the early stages the patient may be mentally alert, but he frequently becomes drowsy and later may suffer attacks of hallucination with periods of extreme restlessness. The tongue is dry and brown. Localized patchy areas of oedema may develop, and arterial hypertension is frequently noted. This

Anorexia

Drowsiness and hallucinations

Oedema

may develop over a period of days, and systolic pressures exceeding 200 millimetres of mercury are often encountered.

Onset

In some cases, however, the onset may be extremely insidious, and the gravity of the situation escapes clinical recognition and is realized only when biochemical investigations are undertaken. Oliguria is always present, and occasionally there may be complete anuria. Examination of the urine does not always indicate the severity of the illness, because the specific gravity remains constant between 1·014 and 1·018, and the excretion of urea is fixed between 0·9 and 1·6 milligrams per cent. An acid pH is the rule.

Oliguria

Examination of the urine

5. BIOCHEMICAL FINDINGS

Blood urea

One of the most remarkable features of acute uraemia is the rapidity with which the blood urea and non-protein nitrogen will rise. The blood urea may frequently reach 200–300 milligrams per cent in the course of 48 hours, with a fall in serum chlorides and alkali reserve. At the same time there is a rise in serum potassium and inorganic phosphate; the former may rise to 40 milligrams per cent when muscle destruction is present. As the condition progresses the blood serum shows a fall in calcium and a reversal of the normal albumin-globulin ratio.

Blood potassium

Prognosis

Prognosis is relatively good if the blood urea does not exceed 200 milligrams per cent by the sixth day. The critical period of the illness occurs between the sixth and the tenth day, when death is most likely to occur.

Critical period

6. TREATMENT

Even with improved methods of treatment, the mortality rate from acute uraemia still remains extremely high. It is therefore important to adopt any measure which can prevent the onset of acute uraemia: thus it is essential before major operations are contemplated to correct anaemia, and the electrolyte and water balance, and so to husband full function of the kidneys. Shock, should it develop, must be combated by all possible methods. Although Trueta (1945) has suggested that the changes in renal haemodynamics may be prevented by splanchnic or spinal block, this form of therapy is not always successful.

Shock

(1) Conservative

The response to conservative treatment is usually good, provided there is no evidence of haemolysis of blood. Treatment entails the restriction of all fluids to less than 1,000 millilitres per day and the control of the electrolyte balance. The limitation of fluid is of importance, for the circulation may quickly become overloaded, and this is followed by peripheral vascular failure and pulmonary oedema. Fluid should be given by the intravenous route and must always be carefully controlled. A gastric tube with continuous suction will relieve the unnecessary distress of vomiting, and will also reduce the level of the serum potassium and urea.

Restriction of fluids

Control of fluid

In practice it has been found unnecessary to correct the level of the carbon dioxide combining power unless it falls below 30 volumes per cent. In the presence of hypochloraemia care should be taken that 9 grammes of sodium

chloride are assimilated daily. The use of sodium sulphate has now been superseded to a great extent; it may, however, be of value at the onset, as soon as it is realized that an incompatible blood transfusion or sulphonamide anuria has occurred; it should never be given when uraemia is established. *Sodium sulphate*

(2) Renal decapsulation

With the object of relieving increased intrarenal pressure many surgeons have advocated bilateral renal decapsulation, but although the procedure is simple, it is now clear that it does not improve the function of the kidney; it is unjustifiable to submit a patient who is desperately ill to such a measure.

(3) Fat diet

Recently, Bull, Joekes and Lowe (1949) have confirmed the fact that a high fat diet largely prevents the formation of urea and toxic products, and they claim that this method is the one of choice in the moderate case. They have overcome the distaste for the high fat diet by giving the food in fluid form through a polythene catheter introduced into the stomach. They, too, stress the importance of the limitation of fluid. *Moderate case*

(4) Dialysis

During recent years much interest has been focused on attempts to remove toxic products which accumulate in the blood as the result of kidney failure. The treatment is based upon the fact that the toxic products of metabolism present in the extra-cellular fluid are dialysable. If the toxaemia can be controlled temporarily the kidney tissue will regenerate *Principles*

The dialysis of toxic products can be accomplished by one of three ways: first, by intra-intestinal dialysis; secondly, by trans-peritoneal dialysis; and thirdly, by dialysis of blood. The critical factor in each case is the composition of the dialysing fluid. *Methods*

(a) *Composition of dialysing fluid*

The dialysing fluid must be adjusted to the needs of the patient, and its composition depends upon whether there is dehydration or oedema, upon the concentration of the important electrolytes in the blood, and upon the electrolyte content of the body as a whole. *Adjustment to suit patient*

The salts are in concentration similar to that of the blood, and water will be taken up selectively to meet the requirements of the body. This obviates unnecessary and dangerous intravenous therapy. If the water balance of the patient appears normal, the solution as described by Kolff (1944) or Odel, Ferris and Power (1948) may be used. Substances of large molecular weight should be added to balance the total blood osmotic pressure. *Solution*

Dextran	–	–	2·75–3·5 g.
Glucose	–	–	0·75 g.
Sodium chloride	–	–	0·61 g.
Potassium chloride	–	–	0·04 g.
Magnesium chloride	–	–	0·01 g.
Calcium chloride	–	–	0·01 g.
Sodium bicarbonate	–	–	0·25 g.
Sodium biphosphate	–	–	0·005 g.
Apyrogen water	–	–	100 ml.

Dextran

Dextran may be used for the purpose, and the above solution has been used with success in the artificial kidney and in intra-intestinal dialysis. The *p*H, which is normally 8·4, may be altered by bubbling carbon dioxide through the solution.

(*b*) *Intra-intestinal dialysis*

(i) *Indication.*—This form of therapy is particularly useful when the probable occurrence of uraemia has been anticipated and the severity of the illness is moderate. It is particularly valuable after haemorrhage or when the patient shows evidence of cardiac failure. Unfortunately, the amount of urea and other products which can be withdrawn is small in quantity. The principal disadvantage of intra-intestinal dialysis is that it may take some days before the tube can be placed in position, and any dispacemlent must be checked by skiagrams.

Disadvantage

Triple-bore tube

(ii) *Technique.*—A special triple-bore tube is introduced into the intestinal tract. Such a tube has already been described by Maluf (1948) and Black and Stanbury (1948). The end of the shorter tube is allowed to lodge in the jejunum, and through this a dialysing fluid is allowed to flow onwards along the intestinal tract, while the mucous membrane acts as a dialysing membrane. The end of the longer tube lodges either in the caecum or in the lowest part of the small intestine; through this tube continuous suction is maintained. During the passage of fluid through the small intestine, the toxic products, including urea, are absorbed into the dialysing fluid, which is then extracted by means of suction. The fluid is prevented from escaping down the intestine by means of a small rubber balloon attached to the third section of the tube, which is inflated with air in a manner similar to that of a Miller-Abbott tube. The dialysing fluid is best introduced by means of an ordinary blood-transfusion giving set, and the flow so controlled that 1–2 litres enter every hour.

Continuous suction

Introduction of fluid

(*c*) *Peritoneal dialysis*

(i) *General considerations.*—The peritoneum presents a large surface of semi-permeable membrane, across which water and the solid constituents of the blood, other than cells and protein, pass with the greatest ease and rapidity. In peritoneal dialysis the composition and osmotic pressure of the washing fluid is therefore of the utmost importance if rapid and dangerous changes in the extra-cellular fluid are to be avoided.

Semi-permeable membrane

Dialysis may overload the circulation and precipitate pulmonary oedema and cardiac failure; it may dehydrate the patient or deprive him of essential salts if the procedure is not controlled by frequent reference to the blood chemistry. An efficient pathological service is the *sine qua non* of this treatment of uraemia.

Dangers

(ii) *Indications.*—The treatment of uraemia by peritoneal dialysis is indicated in acute suppression of urine when there is every reason to believe renal failure to be temporary and reversible. It is a dangerous procedure and should be held in reserve until all other remedies have been applied to attempt the restoration of renal function and the relief of uraemia. With this reservation, peritoneal dialysis is indicated in uraemia due to any of the causes given earlier.

Temporary renal failure

(iii) *Technical considerations.*—Lavage of the peritoneal cavity may be either

intermittent or continuous. For intermittent lavage, fluid is run into the peritoneal cavity, held there while dialysis takes place and then evacuated; in the second method, fluid is run continuously into the peritoneum through a tube placed to one side and is then allowed to escape freely from another tube placed at a distance from the first. *Intermittent lavage*

In the authors' experience, intermittent injection and withdrawal of fluid is preferable, for the continuous flow of fluid tends to be canalized by omental and peritoneal adhesions and a great reduction of available peritoneal surface follows.

(iv) *Insertion of peritoneal tube.*—Under a local anaesthetic a small muscle-split incision is made in the right iliac fossa and a polyvinyl plastic tube, ¼ inch internal diameter and 8–12 inches in length, is inserted in a downward direction towards the pelvis. The peritoneum is closed by a purse-string suture around the tube and the abdominal wall is then sutured in layers; sealing is completed by collodion and Elastoplast dressings. Lateral windows in the tube are avoided as they, and the tube, soon become blocked by omentum or bowel. *Closure of peritoneum*

If continuous irrigation is preferred to intermittent peritoneal lavage, the first tube is inserted as described above, but it may be placed higher in the abdomen, even in the epigastrium, and it need not project more than 2 inches into the peritoneal cavity. The second, or outflow tube, which may be of polyvinyl plastic or a perforated metal sump drain (as used in the ordinary mechanical sucker) traverses the abdominal wall in such a manner that the wound is sealed as above and the tip of the tube reaches the bottom of the pelvic peritoneal pouch. *Continuous irrigation*

(v) *Method of dialysis* —As soon as the patient is returned to bed, and under the strictest aseptic precautions, a suitable flask is connected to the peritoneal inflow tube by about 3 feet of rubber tubing, including a drip feed and suitable screw clamps to control the rate of flow. The level of the flask during inflow should be about 4 feet above the patient.

If continuous irrigation is to be used, a 4-foot length of rubber tube is connected to the inner metal tube of the sump drain, or if there is no inner tube, a suitable catheter is passed down to the bottom of the sump drain leaving enough space for the free passage of air alongside. The outflow system is assisted by a small electric pump or by siphon bottles.

When all is ready, the dialysing fluid is allowed to run into the peritoneal cavity as rapidly as the comfort of the patient allows. Rapid inflow distends the peritoneal cavity and makes available a large surface for dialysis. If intermittent lavage is used, 2 litres are run in (this usually takes 5 minutes) and the tube is clamped How long the fluid should remain before being released depends on the time it takes the dialysable substances in the blood and peritoneal wash to reach equilibrium. Experience has shown that the urea content of the fluid reaches that of the blood in 2 hours. Therefore, at the end of 2 hours the outflow tube clamp is released and the peritoneum drained, a process which occupies only a few minutes. The flow is brisk at first, and as it diminishes a little gentle suction or siphonage may be employed. *Rapid inflow* *Urea content of fluid and blood*

The lavage is then repeated until such time as the general condition of the patient or the restoration of kidney function indicates that the method may be discontinued. Dialysis may be maintained for several days if necessary. *Indications for discontinuance*

(d) Blood dialysis

(i) *General considerations.*—In this type of dialysis, the blood is led from the body, after full heparinization of the patient, into an apparatus that uses Cellophane tubing as a dialysing membrane. After passage through this tube, the blood is returned to the body by means of a suitable vein. While passing through the Cellophane tubing, the tube is surrounded by a dialysing fluid which enables the urea and other toxic products to pass into it. In the first apparatus—that described by Kolff (1944)—a Cellophane tube was wound round a rotating drum. By this means, a very small quantity of blood was spread over a very large surface. This apparatus had the disadvantage that the dialysing fluid was open to the air, and it was difficult to control the volume of blood outside the body at any one time.

Return of blood to body

Improved apparatus

Since that time other forms of apparatus have been described by Murray (1947), Allwall (1947) and Skeggs and Leonard (1948) which are less bulky and easier to handle. Many are enclosed in such a way that the amount of blood external to the patient remains constant and the dialysing fluid remains sterile. This is important, because, although the Cellophane will prevent the passage of bacteria, there may be dialysis of the products of bacterial growth, which may prove toxic.

Larger extraction

(ii) *Indications.*—The use of this method is specially indicated when large quantities of urea or toxic products must be removed from the patient. Experience shows that the amount extracted exceeds that withdrawn by peritoneal dialysis and intra-intestinal dialysis. It is particularly indicated after operations on the intestinal tract, and when intra-intestinal and peritoneal dialysis are not possible.

Contra-indications

In view of the fact, however, that full heparinization is required, its use is not indicated when active bleeding is present, nor is it advised when cardiac failure has already occurred. At the present time this form of treatment is still in the experimental stages.

Return flow

Constant volume

Maximal temperature

(iii) *Technique.*—The apparatus is assembled and sterilized. Usually it is necessary to boil the Cellophane tube, since it does not stand up well to autoclaving. The apparatus is then filled with donor blood and a return flow is established, usually into a vein of large calibre. The radial artery or a large vein is then exposed and a cannula is inserted. An injection of 50,000 units of heparin is given and the blood is allowed to flow into the cannula connected to the apparatus. While the dialysis is in progress, care is taken to maintain a constant volume within the apparatus. Usually dialysis can be achieved at the rate of from 7 to 11 litres per hour. The dialysing fluid should be exchanged at the rate of 20 litres in one hour in order to produce a constant fall. This ensures that approximately 100 milligrams of urea are removed in one hour if the urea exceeds 300 milligrams. The apparatus is maintained at a constant temperature which should be about that of the body but must not exceed 37° C. Throughout dialysis heparin should be allowed to run into the blood in order to maintain anticoagulation. In the event of haemorrhage occurring it is quickly controlled by the use of protamine sulphate and a transfusion of fresh blood.

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[References to other titles are given under Uraemia in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 12, p 379.]

URETER—TRANSPLANTATION OF

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1. DEFINITION

335.] Transplantation of the ureter implies its anastomosis to the large intestine; deviation of the urine can also be accomplished by cutaneous ureterostomy. Re-implantation of the ureter into the bladder, uretero-cystostomy, or into the renal pelvis, uretero-pyelostomy, is not considered here.

2. HISTORY AND METHODS USED

Fistula

The first recorded uretero-intestinal anastomosis was by Simon of St. Thomas's Hospital in 1851 in a case of ectopia vesicae. He established a fistula between the ureter and the rectum on each side by means of a stitch inserted from an ingenious catheter passed up the ureter (Simon, 1852). The same principle of communication by means of an artificial fistula was revived by Coffey in his third method in 1930. The size of the orifice made in this way is always uncertain. In 1878 Thomas Smith, Surgeon to St. Bartholomew's Hospital, transplanted the left ureter extraperitoneally into the descending colon by direct anastomosis (Smith, 1879); there was a faecal and urinary fistula which persisted for 14 months. When it healed the right ureter was transplanted into the ascending colon but the child died 2 days

Direct implantation

later from uraemia. At necropsy the left kidney was found to be destroyed, and the right was soft and enlarged; Smith concluded that "a permanent and direct communication between the ureter and bowel is of itself a fatal lesion". Subsequent workers attempted to prevent ascending infection by various means.

Burial of the entering ureter in the bowel wall after the manner of Witzel's gastrostomy was used successfully by Stiles (1911); it reduces the likelihood of leakage. Maydl (1894) devised the implantation of the trigone with both ureteric orifices into the sigmoid colon, and Peters (1901) and Lendon (1906) left a rosette of bladder at each ureteric orifice which was implanted into the rectum. The preservation of the ureteric orifice is not applicable in cases of carcinoma of the bladder requiring total cystectomy. Coffey in 1911 suggested and carried out transplantation in a submucous trough of the sigmoid colon in an attempt to produce a valvular action at the new orifice. In his second method in 1925 he added an indwelling ureteric catheter, and in his third method in 1930 Coffey advocated a transfixion suture together with the submucous implantation, thus reverting to the fistula principle of Simon for the formation of the orifice. Another method of delaying the actual opening into the bowel until the ureter has healed in its submucous bed is achieved by burying the undivided ureter in the bowel wall as a first stage and making the opening at the lower end of the buried ureter some 2 weeks later. This was carried out by Winsbury-White (1933). Hinman (1939), however, showed that in experimental dogs such preliminary burying of the ureter was followed by obstruction in 6 out of 10 cases and by renal infection in 7 cases out of 10.

Muscularizing principle

Intact ureteric orifices

Submucous tunnel

Burial of intact ureter

Davalos (1945) incised the bowel in its transverse axis to minimize bleeding and left a mucosal flap to protect the orifice against retrograde infection. Many ingenious mechanical devices have been used to prevent infection at the time of operation. The most recent descriptions show a return to the original direct method used by Smith, both Nesbit (1949) and Cordonnier (1949) advocating a direct mucosa-to-mucosa anastomosis with no tunnel. It is claimed that modern antibiotics and surgical advances make possible in 1949 what was impossible in 1879.

Mucosal flap

Mucosal union

3. INDICATIONS FOR URETERO-COLIC ANASTOMOSIS

Deviation of the urinary stream is required as a preliminary to total cystectomy, or to by-pass a bladder which is irreparably damaged, is persistently leaking or is too small for satisfactory function. The conditions are as follows:

(1) Congenital defects
- (a) Exstrophy of the bladder
- (b) Severe epispadias

(2) New growths
- (a) Arising primarily in
  - (i) Bladder
  - (ii) Urethra
  - (iii) Prostate
- (b) Secondary invasion of bladder by growths of
  - (i) Colon or rectum
  - (ii) Uterus or cervix

(3) Urinary fistula
 (a) Vesico-vaginal
 (b) Urethro-vaginal
 (c) Urethro-rectal (some cases)
 (d) Vesico-cutaneous
(4) Contracted bladder
 (a) Tuberculous
 (b) Hunner's ulcer
 (c) Persistent chronic infection
 (d) After extensive partial cystectomy
 (e) Irradiation necrosis
(5) Severe injuries of the bladder
(6) Urinary incontinence resisting all other forms of treatment

Congenital defects In the case of the congenital defects many attempts have been made to cure the conditions by plastic operations with little success; transplantation of the ureters with excision of the ectopic bladder is the best treatment.

Neoplasms In new growths of the bladder for which radical surgery is intended, transplantation of the ureters is either a preliminary to or part of the operation of total cystectomy. Some new growths of the urethra, particularly in women, also need total cysto-urethrectomy and there are a few cases of carcinoma of the prostate in which radical cysto-prostatectomy is indicated.

Fistulae Many vesico-vaginal fistulae can be cured by direct closure, but in those which are very large or have broken down after attempts at closure or are due to malignant disease diversion of the urine is the best treatment.

Contracted bladder Contraction of the bladder causes distressing frequency of micturition, in some cases amounting to incontinence. The operation of transplantation of the ureter is particularly valuable in the "thimble bladder" of advanced tuberculous disease when one kidney has been removed, provided that the other does not contain an established lesion (Jacobs, 1949) It is also of use in severe cases of Hunner's ulcer which have resisted other forms of treatment.

Injuries In serious gunshot wounds of the pelvis causing irreparable damage to the bladder but sparing the rectum, transplantation of the ureters may be the best treatment.

Incontinence In urinary incontinence limitation is placed on the operation in neurogenic cases in which the anal sphincter may also be incompetent. Rectal incontinence, unless it can be cured previously, as by a Thiersch operation, is always a contra-indication to uretero-colostomy.

4. SURGICAL ANATOMY

The ureter lies behind the peritoneum but the loop of sigmoid colon most convenient for its reception lies within the peritoneal cavity. It is therefore necessary to bring the ureter within the cavity to perform an intraperitoneal operation, or to bring a loop of bowel outside the cavity for an extraperitoneal operation. In the former case the site of the anastomosis must be covered by peritoneum at the end of the operation. For the intraperitoneal operation a midline exposure is usual; the extraperitoneal approach is from the flank.

(1) Comparison of routes

Advantages of extraperitoneal approach

Each route has its particular advantages and disadvantages; the advantages of the extraperitoneal method are as follows (Riches, 1949).

(a) If leakage occurs there is no danger of peritonitis.

(b) It is possible to stop after one ureter has been transplanted without the necessity of re-opening the same wound for the second operation.

(c) There is less shock, less risk of intra-abdominal complications and of burst abdomen and subsequent hernia.

(d) The exposure for the anastomosis is better.

(e) The midline is left undisturbed for a subsequent cystectomy.

Disadvantages of extraperitoneal approach

The disadvantages of the extraperitoneal operation are:

(a) It involves two incisions for the transplantation and is less suitable if cystectomy is to be done at the same stage.

(b) It does not allow of such complete abdominal exploration.

(c) With a short sigmoid mesentery it may not be possible to bring the lowest loop of colon into position on the right side.

(d) The subsequent course of the ureter is more oblique.

In the intraperitoneal operation there need be less disturbance of the ureter from its bed and less interference with its blood and nerve supply.

(2) Blood supply

The vessels supplying the suprapelvic portion of the ureter are branches of the renal and spermatic (or ovarian) arteries. The pelvic portion is supplied by branches from the superior vesical and middle haemorrhoidal arteries which show considerable variation in their exact site of origin and in their anastomosis with the upper group.

Preservation

It is important to preserve as much of the blood supply as possible to prevent sloughing of the ureter; the higher the origin of the ureteric branches of the superior vesical artery, the better is the outlook from this point of view (Nitch, 1932).

5. PRE-OPERATIVE PREPARATION

General measures — *Diet* — *Intestinal preparation*

When all the necessary investigations have been carried out, including a general assessment of the patient, preparation of the bowel is started about 4 days before operation. A high-protein low-residue diet is given and an attempt made to empty the large intestine by aperients and lavage. Patients vary in their requirements but for most cases a dose of cascara nightly, and paraffin emulsion (½ ounce) once or twice daily, are adequate. High colonic lavage is carried out on alternate days.

Antiseptics

Succinyl sulphathiazole (Sulfasuxidine) is used as an intestinal antiseptic, at least 60 grammes being given during the 4 days' preparation. The initial large dose of 15 grammes is given crushed in milk, and is followed by 3 grammes 4-hourly. Phthalyl sulphathiazole (Sulphathalidine) can be given in smaller doses (1 gramme 4-hourly) as an alternative but does not appear to be so effective. Streptomycin, 0 5 gramme 6-hourly, is given by mouth, and may in time replace Sulfasuxidine. Added vitamins are an advantage, and the patient is encouraged to drink copiously.

6. OPERATIVE TECHNIQUE

(1) Intraperitoneal operation

Position

Incision

The patient is placed in the Trendelenburg position; a subumbilical midline incision is made, the peritoneum is opened and the abdomen explored. The intestines are packed off, leaving the sigmoid colon free in the pelvis.

Exposure of the ureter

The ureter crosses the pelvic brim near the bifurcation of the common iliac artery. The right ureter is located, and the peritoneum is divided on the pelvic wall medial to it by an incision which is convex medially. The peritoneal flap is raised and the ureter exposed and traced downwards towards the bladder. It is clamped near its lower end and divided, and the distal extremity is carbolized and ligated. The proximal end is secured by a light tissue forceps and turned upwards. The further preparation depends on the method of anastomosis to be used. For a tunnelling method (Coffey I) or a muscularizing one (Stiles) it is usual to cut the proximal end of the ureter obliquely at the required level and to pass a suture through the pointed extremity. This suture is of fine chromic catgut and is provided with an atraumatic needle at each end.

Selection of colon

The area of sigmoid colon to be used is selected so that the ureter can lie against it without tension or kinking, and with similar provision for the left ureter. The area is best defined by stay-sutures on atraumatic needles.

(a) *Stiles's method*

A short transverse incision is made through all coats of the bowel into its lumen (Fig. 153 (a)). The needles on the ureteric suture are in turn passed through this opening into the bowel lumen and out again about one inch

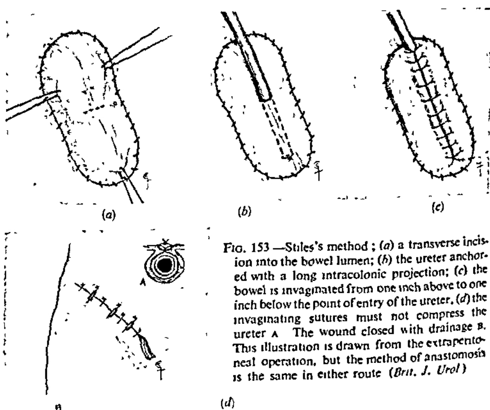


FIG. 153—Stiles's method; (a) a transverse incision into the bowel lumen; (b) the ureter anchored with a long intracolonic projection; (c) the bowel is invaginated from one inch above to one inch below the point of entry of the ureter. (d) the invaginating sutures must not compress the ureter A. The wound closed with drainage B. This illustration is drawn from the extraperitoneal operation, but the method of anastomosis is the same in either route (*Brit. J. Urol*)

lower down, where the two ends are tied (Fig. 153 (b)). The entering ureter is buried in the bowel wall for about an inch above and below its point of entry (Fig. 153 (c)) by means of interrupted Lembert sutures of fine chromic catgut. These should pick up the bowel wall at sufficient distance from the ureter to enclose it without compression (Fig. 153 (d)).

(*b*) *Coffey* 1 *method*

The colon being held on the stretch a one-inch incision is made in the long axis of the bowel through its serous and muscle coats down to the submucosa (Fig.154 (a)). The muscle flaps on each side are undermined by blunt dissection and held back by fine sutures; all bleeding is arrested by fine

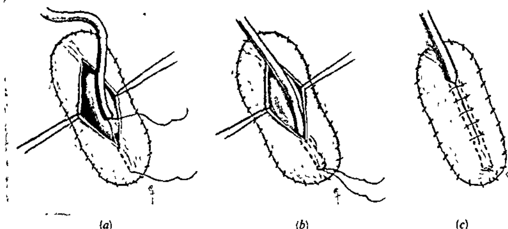


FIG. 154.—Coffey 1 method, (*a*) the colon opened at the lower end and one suture inserted, (*b*) the ureter drawn into the colon and anchored, (*c*) the seromuscular flaps reunited by interrupted sutures. This illustration is drawn from the extraperitoneal operation, but the method of anastomosis is the same in either route. (*Brit J Urol*).

mosquito forceps and diathermy. A stab opening is made at the lower end of the exposed mucous membrane, and the ureteric anchoring sutures are passed in turn through this opening and out about one inch lower down, where they are tied (Fig. 154 (b)) The two muscle flaps are united by interrupted sutures of fine chromic catgut or fine tantalum, and the anchoring suture is buried (Fig. 154 (c)).

The anastomosis is covered by peritoneum from the flap which was made in exposing the ureter; this also serves to fix the site.

The left ureter is transplanted in a similar way at a higher level, and the abdomen is closed without drainage

(*c*) *Reed Nesbit's method*

In Reed Nesbit's method the ureter is slit for 1·5 centimetres and its lower end made spatulate. An incision 1·5 centimetres long is made through one of the taenia coli into the lumen of the sigmoid colon. Direct anastomosis is made by continuous or interrupted sutures of fine chromic catgut passing through all coats of both ureter and colon. The colon is then securely fixed to the parietal peritoneum by numerous catgut stitches for two inches above and below the site of anastomosis. The right ureter is transplanted first and the left at a higher level. The abdomen is closed without drainage.

Direct anastomosis

(d) Cordonnier's method

Maintenance of ureteral peristalsis

In Cordonnier's method emphasis is laid on bringing the bowel to the ureter rather than *vice versa* and on freeing the minimum length of ureter in order to maintain ureteral peristalsis. The ureter is exposed at the pelvic brim and dissected downwards; its division need not be low in the pelvis. Its proximal end is fixed to the bowel by a silk stay-suture placed through the adventitia about 1 centimetre above the cut extremity (Fig. 155 (a)). The bowel is incised down to the submucosa by a longitudinal incision from 1·5 centimetres to 2 centimetres in length and the mucosa is exposed (Fig.155 (b)); it is opened by

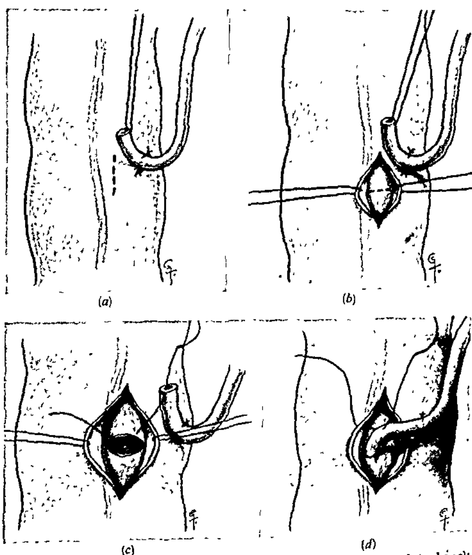


FIG. 155.—Cordonnier's method, (a) proximal end of ureter sutured to bowel; (b) mucosa exposed by incision; (c) suture passing through whole thickness of ureter and mucosa, (d) joining serosa of bowel to adventitia of ureter by suture (*Brit. J. Urol*).

a stab incision and interrupted sutures of fine chromic catgut are passed through the mucosa of the bowel and the whole thickness of the ureter (Fig. 155 (c)). Usually four of these are needed and they join mucosa to mucosa. A second row is used to join the serosa of the bowel to the adventitia of the ureter and at the same time to produce some projection of the ureter into the

bowel lumen (Fig. 155 (d)). The area is covered by peritoneum and fixed to the parietes, and the sigmoid rolled downwards to produce straightening of the ureter. The abdomen is closed without drainage.

(2) Extraperitoneal operation

If the patient is fat a slight Trendelenburg tilt is of assistance; otherwise he is kept flat. *Position*

The right ureter is exposed first by an oblique inguinal incision about 8 inches long (Fig. 156 (a)). *Incision*



The muscles and transversalis fascia are divided in the line of the incision and the peritoneum is pushed medially; the ureter will be found adherent to it (Fig. 156 (b)). It is separated down to the pelvic floor, divided and ligated, and the upper end is turned aside. *Exposure of ureter*

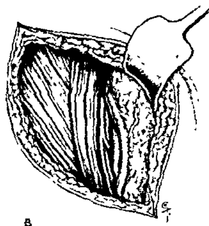


Fig. 156—Extraperitoneal transplantation of the ureter; (*a*) the incisions; (*b*) the right iliac fossa, the ureter is adherent to the peritoneum. (*Brit J. Urol.*)

The peritoneum is opened behind the internal spermatic vessels (Fig. 157) and the lowest loop of sigmoid colon withdrawn and stitched to the margins of the

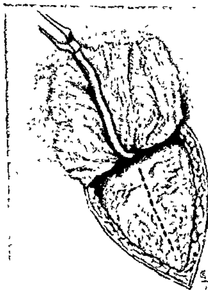


Fig. 157—The divided ureter turned upwards and wrapped in a *moist swab* The dotted line shows the incision to be made in the peritoneum (*Brit. J. Urol.*).

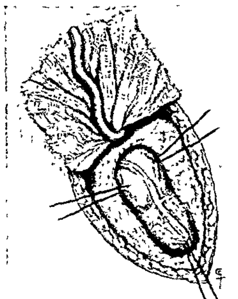


Fig. 158—The peritoneal edges are sutured *to the colon which is held by three stay-*sutures. (*Brit J Urol*).

Exposure of colon peritoneum (Fig. 158) so as to leave a length of about 3 inches of bowel exposed.

The ureter is now implanted by one of the methods previously described, Stiles's technique being the one preferred for this route. The left ureter is *Transplantation* transplanted through a separate left inguinal incision. Drainage is provided on each side.

The operation by the Coffey 1 technique has been described in the section on Tumours of the Bladder (Vol. 2, p. 152).

7. POST-OPERATIVE CARE

Rectal tube At the end of the operation a rectal tube is inserted by which urine is drained into a bottle beside the bed. The tube is retained for about three days and may then be removed during the day and re-inserted for the next two or three nights. Light suction may be applied to it if desired.

Sodium sulphate Isotonic sodium sulphate (4·3 per cent) is given by intravenous drip until secretion is free; early diuresis is the greatest safeguard against ascending infection.

Antibiotics Sulfasuxidine or oral streptomycin is continued for 3 days; penicillin (250,000 units) and streptomycin (0·5 gramme) are given systemically 6-hourly for about three days.

Diet A low-residue diet is continued for five days; then a gradual return is made to normal diet. A glycerin enema is given on the third day if there is distension, and Pitressin (0·5 millilitre twice daily) is also useful for this condition provided that there is no coronary artery disease.

Blood urea The blood urea is estimated on the day after operation and thereafter on alternate days for the first week. The patient usually gets out of bed at the end of a week.

8. COMPLICATIONS

Distension Intestinal distension, due to fixation of the bowel, is often troublesome. It can be avoided to some extent by proper pre-operative preparation, by Pitressin after operation, and by early ambulation.

Leakage Leakage of urine or faeces from the wound during the first few days indicates a break-down of the anastomosis in whole or in part; if the operation has been intraperitoneal it may cause fatal peritonitis unless drainage has been provided. If extraperitoneal, a urinary or faecal leak may persist for weeks or months but will often heal under the influence of streptomycin locally and with the aid of suction. If it does not the site must be explored and re-implantation carried out.

Later leakage is due to sloughing of the ureter (Nitch, 1932) and usually demands re-exploration.

Dilatation There is usually some early dilatation of the ureter and renal pelvis due to diminution of ureteral peristalsis from interference with its blood and nerve supply. Persistent or increasing dilatation is an indication of stenosis of the orifice and will lead to [illegible] lowering of renal function. Such dilatation will be followed by [illegible] and possibly by stone *Calculus* formation. With free drainage fr[illegible] and no obstruction, ascending [illegible] is unlikely to occur.

9. GENERAL PRINCIPLES

Whatever method is chosen there are certain fundamental principles which must be observed. The ureter must be disturbed as little as possible and should not be stripped; there must be no twisting or kinking on its course to the bowel and no undue redundancy. There must be no compression as it enters the colon. The shorter the length of ureter retained below the pelvic brim the better its blood supply. Hence for either of the direct mucosa-to-mucosa methods, in which the success of the anastomosis depends largely on a good blood supply, an intraperitoneal route is essential. The Nesbit method has been used by the extraperitoneal route with success in some cases but in others a leak has occurred. *Ureter*

On the other hand the lower in the colon the transplantation is made the less the interference with bowel function. If the fixed rectum could be used there would be no need to interfere with the normal mobility of the sigmoid colon. The present view is that the maintenance of ureteral peristalsis is of more importance than the non-interference with bowel peristalsis; in practice a compromise must be reached and it is usual to choose the part of sigmoid colon which lies most convenient to the ureters whilst preferring the lower part of the sigmoid loop. For any intraperitoneal method fixation of the anastomosis is imperative. *Bowel*

It is not essential to use one of the taenia coli as the site of junction; Grey Turner (1948) implants the ureter obliquely across the side of the bowel.

In no case should the ureter be joined to the caecum; such a condition may lead to disturbance of water absorption leading to diarrhoea, dehydration, and death from uraemia. *Caecum*

The actual technique of the anastomosis requires the greatest care; a simple method is more likely to succeed than an elaborate one and in this respect the Stiles method is superior to that of Coffey, moreover it avoids the risk *Technique*

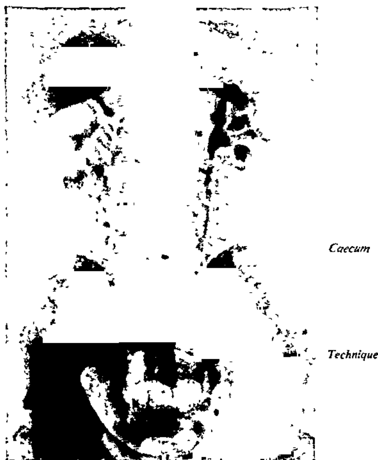


FIG. 159.—Carcinoma of bladder. Excretion urogram before operation—both ureters and calices are dilated (*Brit. J. Urol.*)



FIG. 160.—Carcinoma of bladder. Excretion urogram 16 days after bilateral intraperitoneal transplantation of the ureter by Cordonnier's method. There is no added dilatation (*Brit. J. Urol.*)

Suture material

of haematoma formation in the wall of the bowel which is a potent cause of infection and leakage. Fine chromic catgut (0000) should be used for suture; fine tantalum (0 003 inch) on atraumatic needles provokes less tissue reaction but is more difficult to use.

Stenosis

Excessive suturing may make the anastomosis more secure but is more apt to lead to later stenosis which will ultimately destroy the kidney. The advantage of the direct mucosal methods is that they allow of immediate drainage from the ureter into the bowel; whether they will be subject to later stenosis remains to be seen (Figs. 159, 160). In any tunnelling method narrowing is apt to occur at 3 sites

(1) Where the ureter enters the bowel; too tight suturing at this point must be avoided.

(2) Within the tunnel from infection of a haematoma, haemostasis must be complete.

(3) At the new ureteral orifice. The best results have been attained when there is a small ureteric papilla projecting into the bowel covered by mucous membrane (Fig. 161). This is attained by leaving a good length of ureter within the bowel lumen; the excess sloughs away just as it does when the upper end of the ureter is joined to the renal pelvis in a plastic operation for hydronephrosis.

Bilateral transplantation

Simultaneous bilateral transplantation has the advantage of reducing the number of operations and should be done whenever the condition of the patient permits. When it does not, an interval of 2 or more weeks may safely be left between the operation on the right side and that on the left provided that the function of the 2 kidneys is approximately equal. The extraperitoneal method lends itself well to unilateral transplantation and this is probably the safest method of all. There is a tendency now to carry out transplantation and cystectomy at a single operation and in this case the intraperitoneal route through one incision should be used. It is possible in some such cases to make the anastomosis subperitoneal below the newly formed pelvic peritoneal floor.

Non-functioning kidney

A non-functioning kidney may occasionally recover its function after transplantation provided the duration of loss of function is not too great. If it does not recover it is liable to infection and it should then be removed. If one ureter only has been transplanted and the other kidney is infected and is not functioning, the infected kidney must be removed without delay.

Drainage

In the extraperitoneal method, drainage of the site for 3 days has no disadvantages and many advantages should a leak occur. In the intraperitoneal route drainage is usually omitted owing to the possibility of subsequent intra-abdominal adhesions. If it is employed the drain must pass to the retroperitoneal tissue at the site of the anastomosis and this interferes to some extent with the complete exclusion of the junction from the peritoneal cavity and may form the site of an adhesion of bowel with subsequent intestinal obstruction.

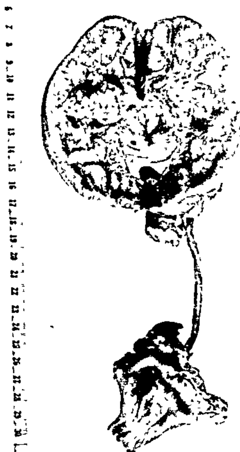


FIG. 161.—Specimen of ureteric transplanation by Stiles's method (extraperitoneal) in a case of inoperable carcinoma of the bladder (*Brit. J. Urol.*).

10. CHOICE OF METHOD

For a single-stage transplantation and cystectomy the Cordonnier method is now preferred, but for a very ill patient the Stiles method by the extraperitoneal route is that of choice. The latter will be found to be the safest method for a surgeon not experienced in the operation.

Children

In a child with exstrophy of the bladder it has been the custom to wait until the age of 5 years is reached, and to transplant one ureter at a time. The present tendency is to operate at about one year, and to transplant both ureters at the same time (Poole-Wilson, 1949).

11. RESULTS

After successful uretero-colic anastomosis the sigmoid colon forms a reservoir which takes the place of the bladder. Urine can be retained usually for 4 or 5 hours by day, and often through the night. There may be difficulty at first in distinguishing wind from water and the patient learns to avoid flatus-producing foods.

Late results

Late results depend on the state of the renal function and particularly

on the avoidance of stenosis at the anastomosis. In malignant cases the late results depend largely on the possibility of complete removal of the bladder.

Operative mortality

Long survival

In 60 cases of extraperitoneal transplantation of the ureters of which 47 were for malignant disease there was an operative mortality of 5, or 8·3 per cent (Riches, 1949). Long-term survivals in cases of exstrophy of the bladder have been reported by Gouverneur (1947), 30 years, Hinman (1947), 28 years, and Grey Turner (1948), 33 years. In cases of carcinoma of the bladder following total cystectomy Hellstrom (1947) reported 2 cases surviving for more than 5 years and one of the writer's cases has survived 5 years after operation. The symptomatic relief especially in the cases of urinary incontinence from fistula or ectopia is such as to render a social outcast able to play a normal part in life.

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[References to other titles are given under Ureter—Transplantation of, in the Index Volume.]

URETHRA AND BLADDER: CONGENITAL MALFORMATIONS

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PART I

HYPOSPADIAS

1. DEFINITION

336.] Hypospadias is the name given to a congenital malformation of the penis and urethra in which the urethra opens, at a site proximal to its normal position, on the ventral surface of the penis or on the scrotum or perineum.

2. CLINICAL PICTURE

The appearance of the genitalia varies from that seen in the mild form, in *Appearance* which the urethra opens on the glans but ventral to its normal position on the summit of that structure, to that of the severe form in which the urethra opens on the perineum. In severe cases the resemblance of the genitalia to those of the female may cause considerable doubt about the sex of the individual: this is specially so when the penis is so small as to resemble a large clitoris Determination of sex is made still more difficult when, as is *Sex determination* frequently the case, the testes are absent from a cleft scrotum and cannot be palpated in the inguinal regions.

The prepuce is always cleft on the ventral aspect and redundant on the dorsal side.

Ventral curvature

Associated with the failure of urethral development there is ventral curvature of the penis which is accentuated during erection of the organ. This curvature is present to some extent in all cases, being slight in the milder forms and usually progressively more pronounced as the opening of the urethra approaches the perineum. In some cases there is a considerable degree of torsion of the penis and in these the median raphe commonly deviates to one or other side of the midline.

3. CLASSIFICATION

The degrees of hypospadias are usually classified according to the position of the urethral opening and are described as glandular, coronal, penile, peno-scrotal, and perineal. From the practical point of view, however, such a classification cannot serve as a guide to treatment requirements: the first stage of surgical treatment is the correction of the ventral curvature of the penis and this, resulting in posterior displacement of the hypospadiac opening, converts cases from coronal into penile, penile into peno-scrotal, peno-scrotal into scrotal and scrotal into perineal.

4. AETIOLOGY

The terminal part of the urethra is developed by invasion of the glans by a solid plug of epithelial cells, the central of which have broken down to form a tube by the seventh month of foetal life.

Fusion of folds

The rest of the urethra is formed by the fusion of the inner genital folds over the urethral groove. "These folds, similar in both male and female embryos up to the eighth week, have fused in the normal male embryo by the end of the tenth week" (Gatewood, 1936). It is usually considered that hypospadias results from the failure of fusion of these folds but such an assumption is difficult to reconcile with the actual findings. There is not always a mucous membrane gutter distal to the urethral opening although

Extensive aplasia

aplasia, a failure of development of the corpus spongiosum

(represented by a fibrous cord) in the region distal to the abnormal urethral orifice. Even if this somewhat vague explanation is accepted, it is difficult to understand why this cord should be short and produce ventral curvature; it cannot be thought of as scar tissue and therefore prone to contraction.

McIndoe (1948) gives a sound practical description when he states "The urethra is obliterated distally in the hypospadiac, it is longitudinally and dorsally split in the epispadiac".

5. TREATMENT

Abnormalities in the glans penis urethra do not give rise to deformity of the penis and at most lead to a slightly abnormal projection of the urinary stream: they are of little importance and seldom call for treatment.

The treatment of hypospadias is surgical and has two chief aims. (1) to provide a normally placed urethral orifice and a normally directed stream of urine; and (2) to correct the ventral curvature so that the penis will be straight during erection and allow normal coitus and impregnation to take place. *Chief aims*

(1) Correction of ventral curvature

(a) *Time of operation*

The ventral curvature should be corrected before any attempt is made to reconstruct the missing portion of the urethra. This part of the treatment should be carried out as soon as the child has developed urinary control, usually when he is 2–3 years old. Early operation releases the corpora cavernosa and allows them to develop normally. Occasional cases are encountered in which the abnormal opening of the urethra is so small that meatotomy is called for in very early infancy. *Early age* *Meatotomy*

(b) *Principles of treatment*

The ventral curvature is due to a combination of two factors, both requiring correction. The more important of these is a longitudinal band of connective tissue attached in front in the region of the corona and behind to the urethra. Associated with this, there is a varying degree of skin shortage on the ventral surface of the penis. The band of connective tissue must be removed completely and the skin on the ventral surface must be increased in length by rearrangement or addition. *Connective tissue* *Skin shortage*

(c) *Technique*

In the milder forms, ample skin will be found on the ventral surface of the penis to allow of straightening once the fibrous cord has been completely removed. It is our practice in such cases to employ a transverse incision, between glans and urethral opening, which is later sutured longitudinally (Fig. 162 (a)). When it seems likely that there may be slight skin shortage we employ a V-shaped incision, closing the wound in the form of a Y (Fig. 162 (b)). On other occasions we plan our incisions in such a manner as will allow rearrangement of skin in the well-known Z-plasty fashion when the wound is closed (Fig. 162 (c)). Through such incisions the fibrous band representing the missing portion of urethra and corpus spongiosum is fully exposed and completely removed. During this process the penis is stretched dorsalwards over the fingers of the surgeon's left hand. As the fibrous cord is removed the distance between glans and urethral opening gradually increases until the penis can be made to assume an overcorrected position. It is sometimes necessary to carry out further freeing in the neighbourhood of the urethral orifice before the urethra will slide backwards in relation to the adjoining corpora cavernosa and the real extent of the defect is demonstrated. *Transverse incision* *Z-plasty*

In the severe forms, when the curvature is very pronounced, it is quite obvious that there is real skin shortage on the ventral surface. In such cases additional skin must be found to cover the large defect left by the straightening procedure. The redundant prepuce has proved a most convenient and valuable source of supply and ingenious methods have been devised for transporting it from the dorsal to the ventral aspect of the penis by Blair, *Severe forms* *Skin from prepuce*

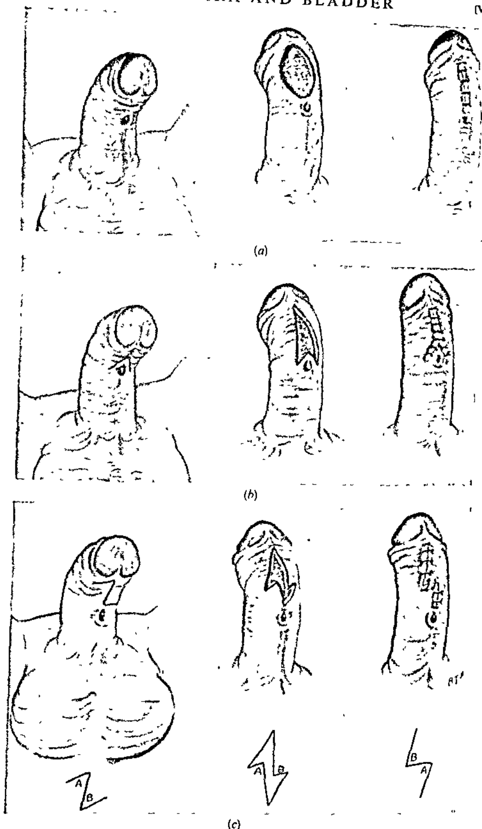


FIG 162.—Correction of ventral curvature (a) transverse incision sutured longitudinally after removal of the fibrous cord and straightening; (b) V-shaped incision sutured in the form of a Y after removal of the fibrous cord and straightening; and (c) Z-plasty transposition of two triangular skin flaps after removal of the fibrous cord and straightening

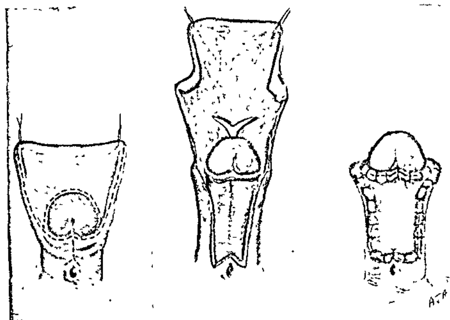


FIG 163.—Ombrédanne preputial flap used to provide additional skin for the ventral surface of the penis when the raw surface left by straightening is large

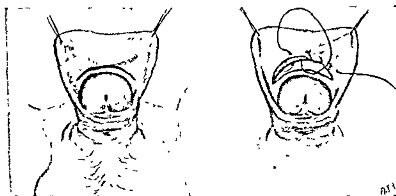


FIG 164.—The Edmunds first stage procedure Prepuce converted into a small tubed pedicle by formation of button-hole.

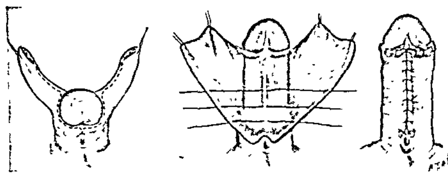


FIG. 165.—The Edmunds second stage procedure.

Brown and Hamm (1933), Edmunds (1926) and Ombrédanne (1932). Browne (1936) inserts it into an incision on the dorsum of the penis thus leaving ample skin on the sides of the penis to slide round and give closure by approximation on the ventral surface. Ombrédanne devised his preputial flap as covering material after reconstruction of the urethra in the second stage of his procedure but we often employ it at this first stage when the raw surface left by straightening is large (Fig. 163).

The first and second stages of Edmunds's procedure for the correction of hypospadias provide an alternative (and justly popular) means of providing this additional skin for the ventral surface. The technique is illustrated by Figs. 164 and 165. The prepuce is transfixed by a dorsal incision just distal to the corona. The margins of the buttonhole thus produced are united by fine sutures. By this means the prepuce is converted into a small tubed pedicle deprived of its main blood supply from the dorsal vessels but gaining a compensatory collateral circulation from the sides of the penis.

Incision of prepuce

Two to three months later the small tubed pedicle is divided at its mid-point. A midline longitudinal incision is made on the ventral aspect of the penis from urethral orifice to glans and continued laterally a short distance from the glans on either side to join the seam of the preputial "tube". It is continued along this to the cut end. The skin of the body of the penis is reflected and the two halves of the preputial "tube" are opened out. This manoeuvre provides two surprisingly large skin flaps which readily cover even the largest raw surface left by the straightening procedure. These flaps are approximated in the midline by sutures which pick up deep tissue and so obliterate dead space.

Skin flaps

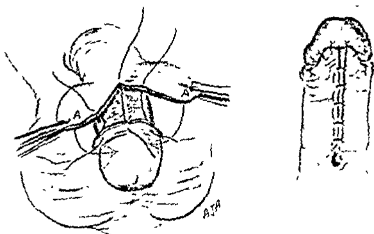


FIG. 166.—Blair's method of transferring preputial skin to the ventral surface at one operation, in principle, a combination of the Edmunds first and second stage procedures

Blair, Brown and Hamm employ a technique similar in principle to that of Edmunds but bring the preputial skin to the ventral surface in a one-stage operation (Fig. 166).

Very occasionally a case of hypospadias is presented in which the redundant dorsal prepuce has been removed at circumcision. It should be unnecessary to stress the importance of retaining this invaluable source of skin supply.

Circumcision

(2) Reconstruction of urethra

(a) Time of operation

It should be the surgeon's aim to have the urethral reconstruction completed before his patient reaches school age. We make every effort to complete the work before the child is 5 years old and we fail to understand the arguments advanced by those who advocate procedures which must be deferred until much later. We disagree entirely with Havens (1948) that "the whole programme [that is including correction of ventral curvature] can be deferred until puberty without fear of disadvantage". Surely it is true to say that the sooner a congenital defect is corrected, the better; and surely development must be more natural after successful correction. How can a boy mix happily with his schoolfellows if he has to seek a water closet when he wishes to micturate? In some Asiatic races it is customary to micturate in the squatting position and in these the need for early repair is not so urgent. We hold the view, however, that even in these cases repair should be completed before puberty.

Completion before school age

(b) Principles of treatment

Attempts to employ the appendix, the saphenous vein and other strange grafts, autoplastic, homoplastic, and heteroplastic, have met with no success and surgeons experienced in the treatment of hypospadias shun such experimental procedures. A review of the large number of reported cases indicates that only a small number of operative procedures (and their variations) have stood the test of time. The names of Thiersch, Duplay, Nové-Josserand, Ombrédanne, Bucknall, Edmunds, Blair, Mayo, Cabot and Cecil are associated with the development of these. Elaborate and sometimes fantastic illustrations have found their way into the literature. Those which suggest that there is always a superabundance of skin on the body of the penis, sufficient to provide both lining and covering for urethral reconstruction, are particularly misleading. The few methods which will be described are based on the following sound guiding principles.

(1) It is important that the lining of the reconstructed urethra shall not grow hair otherwise, deposits and concretions will produce complications, however perfect the operation may be from the technical point of view.

(2) It follows, therefore, that the lining of the urethra should be provided by skin from the prepuce, the body of the penis or by a hairless free skin graft.

(3) Covering skin may be obtained from the prepuce, the body of the penis or the scrotum, it being of no great importance to have hairless skin on the ventral surface of the penis.

(c) Technique

The surgical treatment of this deformity is essentially a plastic surgical problem. Meticulous care must be exercised in the handling of the thin skin of the penis. We try to avoid the use of hooks and even fine toothed forceps: when skin [illegible]

Plastic surgery

scrupulously avoided.

We have come to the conclusion after much experience that catgut is undesirable as suture material in the urethral lining; it predisposes to infection and fistula formation and its rate of absorption in this situation is uncertain

Non-absorbable sutures

We use only non-absorbable sutures mounted on atraumatic needles. No. 1 nylon and gossamer silkwork gut on No. 6 eye-curved needles are ideal for this purpose. All lining sutures are of the continuous variety and start and finish on external skin so that they may be found and removed with ease. Superimposition of covering and lining suture lines should be avoided for this also predisposes to fistula formation.

Catheter

When a catheter is used during the operation as a guide in the construction of the urethral tube, liquid paraffin or other greasy preparations should be avoided: they prevent early adhesion of wound edges. Glycerin or some other water-soluble agent may be used with impunity. We have never found any need for an indwelling catheter or for diversion of the urine.

The success of any operation for hypospadias will largely depend on attention to these rules.

Details of procedure and variations of technique in the reconstruction of the urethra in the average case of penile hypospadias are given below.

(i) *Ombrédanne's procedure with slight modification.*—This method of urethral reconstruction is employed in those cases in which the ventral curvature has been corrected by excision of the fibrous cord accompanied by a local skin plastic but without interference with the prepuce. Lining for the missing portion of the urethra is provided by a flap of hairless skin turned forwards

Lining of hairless skin

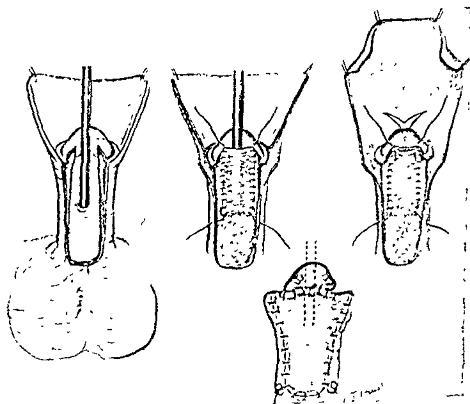


FIG. 167.—Ombrédanne's method of urethral reconstruction with slight modification. The catheter is removed at the end of the operation. The technique of insertion of the lining sutures is very important.

from the body of the penis; covering is supplied by the prepuce. The reconstruction is performed in one stage without diversion of the urinary stream. The technique is illustrated by Fig. 167. A catheter lubricated with glycerin is introduced into the proximal urethra and is anchored to the glans by suture. This acts as a scaffolding over which the urethra is built. Areas of skin, proximal and distal to the urethral opening, suitable for the reconstruction are delineated by pen and Bonney's blue. Each of these areas should be sufficiently wide to provide half the circumference of a normal urethra. The anterior extremity of the distal area corresponds to the point at which the new urethral orifice is to lie: the posterior area marks out a flap which should be of such a length as will allow it, when turned forward, to reach this same point with ease. Incisions are now made along the lateral lines and these are joined at their proximal ends. The flap thus outlined proximal to the urethral opening is carefully raised. When approaching the urethral opening great care must be taken to avoid penetration of the urethra. Distal to the urethral opening the skin adjoining the lateral incisions is undermined inwards for a short distance. The flap is now turned forwards and sutured in position by fine nylon sutures which enter on the skin of the side of the penis, continue forward to approximate lining margins by a "loop-on-the-mucosa" stitch and come out on the surface of the glans. No buried catgut sutures are used. *Incisions* *Suture of flap*

The Ombrédanne preputial flap is now prepared, perforated by the Y-shaped incision (made with due regard to avoiding damage to blood-vessels) and brought over the glans to be sutured in position and so provide covering for the whole defect on the ventral surface.

The ends of the continuous lining sutures are fixed by split shot or by tying over small gauze rolls.

The penis is now wrapped with ribbon gauze soaked in Mastisol or in Whitehead's varnish. This, when dry, provides excellent splintage. The catheter is discarded and blood clot is removed from the new meatus lest it should solidify and cause obstruction. The penis is drawn up on the abdominal wall, covered with gauze and a pad of wool and held in this position by strapping and a T-bandage. *Splintage*

Post-operative discomfort on micturition is minimized by allowing the child to void urine in his bath, after which the parts are carefully dried and powdered. *Micturition*

The dressing is commonly shed spontaneously within a few days of operation. We seldom renew it, depending on frequent baths and careful drying and powdering to keep the parts clean.

Sutures are removed in a good light on the tenth day under sedation or general anaesthesia.

(ii) *Blair's procedure*.—Although we have obtained consistently gratifying results from Ombrédanne's procedure, in its original and slightly modified forms, we have hesitated to use his "*procédé du sac*" when the urethral opening was far back because it appeared to us to carry risk of in-turning hair-bearing skin. In such cases we have been impressed by the procedure devised by Blair, Brown and Hamm (1933) for scrotal hypospadias. The lining of the missing portion of the urethra is provided by broad-based flaps from the sides of the defect, sutured together in the midline. The prepuce, having been used in the treatment of the ventral curvature, is not available *Scrotal hypospadias*

We have come to the conclusion after much experience that catgut is undesirable as suture material in the urethral lining; it predisposes to infection and fistula formation and its rate of absorption in this situation is uncertain. We use only non-absorbable sutures mounted on atraumatic needles. No. 1 nylon and gossamer silkwork gut on No. 6 eye-curved needles are ideal for this purpose. All lining sutures are of the continuous variety and start and finish on external skin so that they may be found and removed with ease. Superimposition of covering and lining suture lines should be avoided for this also predisposes to fistula formation.

Non-absorbable sutures

Catheter

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Lining of hairless skin

(i) *Ombrédanne's procedure with slight modification.*—This method of urethral reconstruction is employed in those cases in which the ventral curvature has been corrected by excision of the fibrous cord accompanied by a local skin plastic but without interference with the prepuce. Lining for the missing portion of the urethra is provided by a flap of hairless skin turned forwards

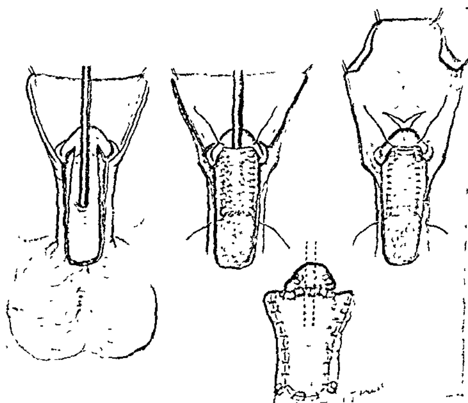


FIG. 167.—Ombrédanne's method of urethral reconstruction with slight modification. The catheter is removed at the end of the operation. The technique of insertion of the lining sutures is very important.

from the body of the penis; covering is supplied by the prepuce. The reconstruction is performed in one stage without diversion of the urinary stream. The technique is illustrated by Fig. 167. A catheter lubricated with glycerin is introduced into the proximal urethra and is anchored to the glans by suture. This acts as a scaffolding over which the urethra is built. Areas of skin, proximal and distal to the urethral opening, suitable for the reconstruction are delineated by pen and Bonney's blue. Each of these areas should be sufficiently wide to provide half the circumference of a normal urethra. The anterior extremity of the distal area corresponds to the point at which the new urethral orifice is to lie: the posterior area marks out a flap which should be of such a length as will allow it, when turned forward, to reach this same point with ease. Incisions are now made along the lateral lines and these are joined at their proximal ends. The flap thus outlined proximal to the urethral opening is carefully raised. When approaching the urethral opening great care must be taken to avoid penetration of the urethra. Distal to the urethral opening the skin adjoining the lateral incisions is undermined inwards for a short distance. The flap is now turned forwards and sutured in position by fine nylon sutures which enter on the skin of the side of the penis, continue forward to approximate lining margins by a "loop-on-the-mucosa" stitch and come out on the surface of the glans. No buried catgut sutures are used. *Incisions* *Suture of flap*

The Ombrédanne preputial flap is now prepared, perforated by the Y-shaped incision (made with due regard to avoiding damage to blood-vessels) and brought over the glans to be sutured in position and so provide covering for the whole defect on the ventral surface.

The ends of the continuous lining sutures are fixed by split shot or by tying over small gauze rolls.

The penis is now wrapped with ribbon gauze soaked in Mastisol or in Whitehead's varnish. This, when dry, provides excellent splintage. The catheter is discarded and blood clot is removed from the new meatus lest it should solidify and cause obstruction. The penis is drawn up on the abdominal wall, covered with gauze and a pad of wool and held in this position by strapping and a T-bandage. *Splintage*

Post-operative discomfort on micturition is minimized by allowing the child to void urine in his bath, after which the parts are carefully dried and powdered. *Micturition*

The dressing is commonly shed spontaneously within a few days of operation. We seldom renew it, depending on frequent baths and careful drying and powdering to keep the parts clean.

Sutures are removed in a good light on the tenth day under sedation or general anaesthesia.

(ii) *Blair's procedure.*—Although we have obtained consistently gratifying results from Ombrédanne's procedure, in its original and slightly modified forms, we have hesitated to use his "*procédé du sac*" when the urethral opening was far back because it appeared to us to carry risk of in-turning hair-bearing skin. In such cases we have been impressed by the procedure devised by Blair, Brown and Hamm (1933) for scrotal hypospadias. The lining of the missing portion of the urethra is provided by broad-based flaps from the sides of the defect, sutured together in the midline. The prepuce, having been used in the treatment of the ventral curvature, is not available *Scrotal hypospadias*

for covering. Covering is therefore provided by skin from the scrotum. The urethral reconstruction is carried out in two stages, the first providing the penile urethra and the second anastomosing this to the hypospadiac opening. At this second stage the urine may be diverted by perineal urethrostomy, or a catheter, maintained just within the bladder neck, may be employed. A study of Figs. 168 and 169 will make the steps of the procedure quite clear.

Two stages

When it has been found necessary to employ the prepuce in the straightening stage and the Ombrédanne type of urethral reconstruction is thus impossible,

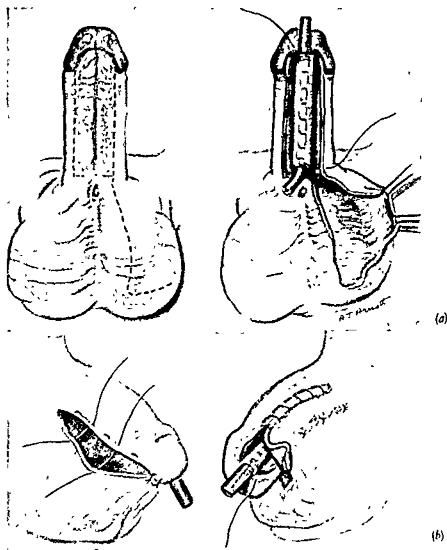


FIG. 168.—Blair's procedure for urethral reconstruction, (*a*) and (*b*) first stage.

we consider Blair's procedure a useful one, as an alternative to Edmunds's stage III, when the skin available on the penis is not sufficient to provide both lining and covering.

(iii) *Nové-Josserand–McIndoe procedure.*—This method is used for urethral reconstruction in cases in which (after correction of the ventral curvature) the hypospadiac opening is situated on the hair-bearing area behind the peno-scrotal junction.

For reasons already stated it is important that the skin used for the lining

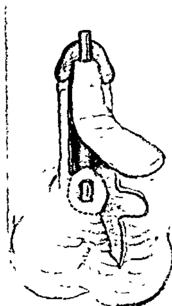
of the urethra shall not grow hair. No local lining flaps free from hair being available, the lining is provided by a thin hairless Thiersch graft. Nové-Josserand (1897) conceived the idea of making a dermo-epidermal urethral tube, introducing the graft on a probe which was removed 8 days later. Any-one conversant with the tendency for free skin grafts to contract will understand why this method failed to achieve its object. The method, revived and popularized by McIndoe (1937), owes its present-day success to recognition of the need to make the lumen of the grafted tunnel considerably larger than the size ultimately required and to maintain the graft in a stretched condition for a minimum period of 6 months.

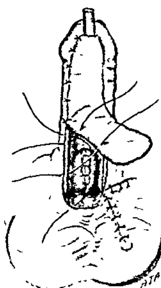
Urethral tube

The ventral curvature is corrected by Edmunds's procedures early in life and urethral reconstruction is deferred until the age of 7 or 8 years. The urethral reconstruction is performed in two stages.

Correction of ventral curvature

(a)





(b)

FIG 169 —Blair's procedure for urethral reconstruction. (a) and (b) second stage

In stage I a thin hairless Thiersch graft, cut from the inner side of the upper arm, is applied, raw surface outwards, to a length of gum-elastic bougie or catheter which just fits inside the barrel of the specially designed trocar (Fig. 170). This instrument is made in different sizes to suit different cases:

the largest size practicable should be employed. The assembled trocar containing the graft-covered bougie is *introduced* proximo-distally through a small incision immediately in front of the hypospadiac opening and, travelling subcutaneously, is made to emerge through another small incision on the glans at the normal site of the external meatus. The point section of the trocar is then removed and the end of the bougie is firmly held by forceps.

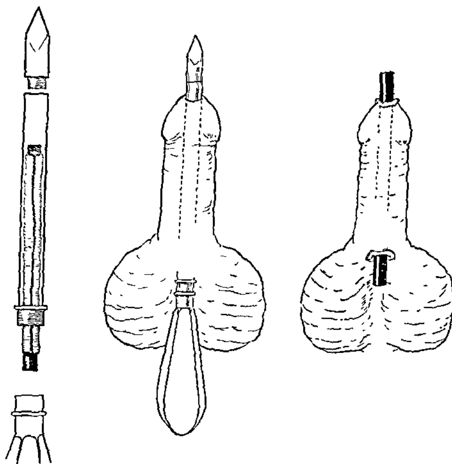


FIG. 170.—*McIndoe's procedure: reconstruction of the urethra by free hairless skin graft*

The barrel of the instrument is then carefully withdrawn leaving the graft-covered bougie in position. The penis is now bandaged with one-inch ribbon gauze soaked in Mastisol or Whitehead's varnish.

A catheter passed into the bladder through the hypospadiac opening is retained for 48 hours to prevent contamination of graft with urine.

Ten days later, the bougie is removed and the grafted tunnel is gently syringed through with saline solution or a mild antiseptic solution. A specially constructed bougie or a fresh length of gum-elastic bougie is inserted. At no time for the next 6 months is this removed for longer than the few minutes required for irrigation and cleansing. The special bougies are made in various sizes and have detachable ends of two kinds, the first to facilitate insertion and the second to prevent them slipping out.

Stage II is carried out 6 months after the first when it is reasonable to expect no further contraction of the graft and when the bougie may be discarded

with impunity. The posterior end of the new urethra is anastomosed to the hypospadiac opening.

Diversion of urinary stream

McIndoe, in his 1937 paper, stated that diversion of the urinary stream was unnecessary at any stage of treatment, but it is to be noted that external urethrostomy is advocated at this stage in a more recent article on the subject (McIndoe, 1948).

Humby (1941) described a one-stage operation in which a skin-graft-covered bougie was employed in much the same manner but at a deeper level from the skin surface. In this operation a stab suprapubic cystostomy is used.

Contraction

We have encountered many difficulties in our attempts to employ McIndoe's procedure and now advocate its use in adults only and in these only when no local hairless skin is available for reconstruction of the urethra. Even 6 months after complete take of a skin graft applied on a large bougie, surprisingly rapid contraction may follow removal of the bougie. We suggest, therefore, that a bougie of at least twice the diameter of the required urethral lumen should be employed.

The anastomosis of skin-graft urethra and hypospadiac opening is a technical problem of considerable difficulty and we have reason to believe that even in experienced hands it not infrequently results in fistula formation.

6. CONGENITAL SHORT URETHRA

Transverse division

McIndoe (1948) reports that he has encountered this condition on only two occasions. The penis is short and ventrally curved: normal erection is impossible. The prepuce is intact. The urethra emerges at the normal site on the glans. The corpus spongiosum and urethra are complete but are too short when compared with the corpora cavernosa. He recommends bold transverse division of the urethra and corpus spongiosum at the level of the corona and the establishment of the urethral defect by allowing the cut ends to slide apart and take up their correct relationship to the corpora cavernosa. The hypospadiac defect thus produced is later repaired by one or other of the procedures already described.

Recently Denis Browne (1949 a and b) has devised an extremely simple method of reconstructing the urethra which, if his claims are substantiated, should replace the more difficult and complicated procedures described above. Readers are advised to consult the original articles.

PART II
EPISPADIAS: ECTOPIA VESICAE

Epispadias is a much rarer condition than hypospadias. Ectopia vesicae (extrophy, exstrophy, or extroversion of the bladder) is fortunately still more rare, occurring in a ratio of 1 in 50,000 and being more frequent in males than in females in the ratio of about 8 to 1.

1. CLASSIFICATION

Thompson (1931) suggested a new classification for congenital defects in this region by which the slighter form of epispadias (in which the proximal part of the urethra is apparently normal and urinary control is present) is grouped with hypospadias under the heading of congenital urethral defects while the severe form of epispadias (inferior congenital fistula) is grouped with ectopia vesicae (superior congenital fistula) in both of which conditions there is urinary incontinence. This seems reasonable and stresses the point that in the severer form of epispadias the defect is something much more serious than a mere deficiency of the urethral roof.

2. EPISPADIAS IN THE MALE

Aetiology

Epispadias in its milder forms in the male may be considered, then, as was hypospadias, a congenital deformity of the penis and urethra. The failure in development is quite different, however, in the two conditions in certain important respects. We have never encountered a case of epispadias in which the urethra opened on the dorsum of the penis with norma or relatively normal penis distal to it. The urethral defect, whatever underdevelopment there may be in its length, always starts in the glans: it is invariably represented by a gutter of varying length and depth lying between abnormally separated corpora cavernosa. This cleft is usually lined, at any rate in its deeper part, by mucous membrane. The prepuce is invariably cleft or missing dorsally and hangs as a redundant fold below. The splaying of the corpora cavernosa gives a characteristic flattened appearance to the upper surface of the penis and there is always some dorsal curvature, more pronounced during erection. This is no doubt due to the shortness of the urethral gutter but we have been unable to find any reasonable explanation why, if epispadias represents purely a split urethra (as appearances suggest) the lateral constituents should be shorter than normal We find it difficult, too, to understand the shift of the urethra from a ventral to a dorsal position and the complete absence of development of the corpus spongiosum. Embryologists are convinced, however, that the same embryological defect is responsible for both epispadias and ectopia, the difference being merely one of degree. Davis (1928) accepts

Commencement of defect

Lining of cleft

Embryological defect

the explanation given by Johnson (1926) which states there is "a cephalad displacement of the cloacal membrane in an early stage of development, before the cloacal tubercle has made its appearance. The cloacal tubercle, developing later, arises below the cloacal membrane so that when the membrane is resorbed, the urogenital sinus opens on the dorsum of the phallus rather than on the ventrum. If the displacement of the cloacal membrane extends on to the primitive abdominal wall, the result will be exstrophy of the bladder· if the displacement is of lesser degree, epispadias alone results".

Severe forms In the severer forms of epispadias the urethral roof is missing throughout the whole length of the penis, the sphincter mechanism is defective and urinary control is completely absent. If the proximal part of the urethral gutter is examined it will be seen that the longitudinal folds of its anterior part give place to radiating folds suggesting the presence of an external sphincter, deficient in its dorsal part.

Pubic symphysis In many of these cases there is failure of development of the pubic symphysis. The shortness of the dorsal surface of the penis may be so pronounced as to suggest that only the glans is present, until this structure is drawn forwards from the skin fold, which often partly hides it, to expose the rudimentary penis.

3. EPISPADIAS IN THE FEMALE

The problem of epispadias in the female has been very carefully studied and analysed by Davis (1928) and much of the following description is quoted from his writings. The two halves, or corpora cavernosa, of the cloacal tubercle do not unite beneath the displaced urethra as they do in the male. In the adult the two halves of the clitoris may be several centimetres apart. There is also failure of union of the labia minora and labia majora and a depressed hairless skin area is present at the site usually occupied by the mons veneris. The urethra opens between the two halves of the clitoris or some distance above them. In the more severe types the urethra is a wide funnel-shaped opening occupying the space between clitoris and symphysis.

Extreme deformity The most extreme deformity of the urethra and aplasia of the sphincter mechanism may be present without symphyseal separation: on the other hand, moderate deformity with good sphincteric control may be associated with wide separation at the symphysis The vagina and internal genitalia are usually normal. In the mildest (vestibular) forms, urinary control is unimpaired, but in the majority of cases incontinence is the rule and is usually complete or nearly so.

4. ECTOPIA VESICAE

External appearances When both bladder and urethra are open there is always associated separation (often wide) of the pubic bones. The external appearances are very characteristic (Fig. 171). The bladder presents as an area of exposed mucous membrane occupying the space between umbilicus and external genitalia where a condition of complete epispadias is present The upper part of the bladder mucosa is red and velvety and bulges forward: the lower part, on which the ureters' open, is paler, smoother and somewhat depressed. Wood

Jones (1912) has described a still more severe variety of ectopia in which two intestinal openings are present on the exposed mucosa. Such cases do not long survive their birth and therefore need not concern us.



FIG. 171.—Ectopia vesicae in a male infant aged 1 week. The bladder protrusion is well seen with a completely epispadiac penis immediately below it. Above can be seen the umbilical cord which was mildly infected. There is a well-formed scrotum containing both testes. The ureters were transplanted into the large bowel, the left at $2^7/_{12}$ years and the right a month later. Bladder mucosa was removed, the abdominal wall was repaired and urethra and penis were reconstructed at 3½ years. He had good rectal control of urine but died of uraemia when 8¾ years old.

5. TREATMENT

(1) Epispadias without incontinence in the male

The repair of the external genitalia in the milder types of epispadias in the male when urinary control is present, or in the more severe types when urinary incontinence has been cured by ureteral transplantation or other means, may justly be considered a purely plastic surgical problem.

Analysis of deformity

Careful analysis of the penile deformity will reveal two factors, dorsal curvature and urethral deficiency, both calling for correction if the organ is to fulfil all its functions.

(*a*) *Correction of dorsal curvature*

The dorsal curvature need not be regarded with the same importance as the ventral curvature of hypospadias: a mild degree of dorsal curvature is compatible with normal sexual function. The curvature is due, as previously mentioned, to a shortage of urethra and, if at all severe, calls for correction before any attempt is made to reconstruct the urethra.

(i) *Time of operation.*—Our cases of epispadias have presented themselves to us in early adult life and we have had no experience of the treatment of epispadias in infants or young children. We believe, however, that as in hypospadias, this correction of curvature should be carried out at an early

age and we should like to deal with it as soon as the child has developed urinary control (usually at about 3 years old) at a time when he may be described as "dry".

(ii) *Technique.*—An incision is made on either side of the dorsal gutter. These incisions are gradually deepened and the mucosa lining the urethral gutter is thus freed from its attachments and allowed to slide back in relation to the corpora cavernosa. The raw surface which this manoeuvre leaves anteriorly is covered by hairless skin brought round from the ventral redundancy and bedded down in that part of the urethral gutter now left without epithelial covering.

McIndoe (1948) has followed a suggestion made to him by Koch. After dissecting out the urethral gutter from the dorsal surface of the penis, he



FIG 172.—Epispadias with urinary control in a youth of 15 years of age No material dorsal curvature, prepuce too short for use in repair Reconstruction by inturned flaps for lining and scrotal flap for covering. At the last operation at age 22 years, the dorsal part of the glans was split and the terminal portion of the urethra transplanted to a more ventral position Photographs taken 3 weeks after this operation show a penis with ample dorsal length, a well-placed meatus and a well-directed urinary stream This patient complains, as do many after the repair of epispadias, of failure to ejaculate, the spermatic fluid is retained unless manually expressed.

viability of what must be a long and relatively narrow flap. Cabot (1937) overcomes the difficulty by placing the penis in a dependent position under a "strap" flap on the anterior surface of the scrotum. Young (1918) employs a technique (Fig. 173) in which the reconstructed urethral tube is left attached to one corpus cavernosum. This corpus is separated from its fellow and rotated in such a way as to bring the urethra near to the ventral surface of the penis in approximately its normal position. Cecil (1932) has practised this ingenious procedure with success. Cabot (1937) complains of the tension on sutures holding the corpora in their new position and has encountered separation and failure on this account.

Urinary stream

Opinions vary in regard to the need for diversion of the urinary stream in these procedures. We have not found it necessary.

(2) Epispadias without incontinence in the female

Epispadias without incontinence in the female does not call for surgical treatment.

(3) Epispadias with incontinence: ectopia vesicae

The treatment of these terribly crippling conditions is an altogether more formidable undertaking. While the plastic surgeon may continue to feel justified in dealing with the reconstruction of external defects we hold that there is a clear indication for close collaboration with the urologist for the work on the bladder and with urologist or general surgeon when ureteral transplantation is to be carried out.

The problem of providing urinary control received the attention of Duplay (1880), Cantwell (1895), Boiffin (1895), Trendelenburg (1906) and Thompson (1920). Occasional successful results were reported but it was left to Young (1922) to devise satisfactory measures for construction of both internal and external sphincters. This work on the bladder neck was epoch-making and pointed to the ideal at which all surgical work on these distressing cases should aim. Once urinary control is established, the condition is converted into one calling only for the simpler reconstructive work on penis and urethra by such procedures as have already been described.

(a) Young's operation for incontinence

Young and his followers have reported many successful results in their treatment of incontinence in patients with epispadias. In 1940 Young applied his technique to a case of ectopia vesicae in a female child about 5 years old and was able to report in 1942 "the first case in which a normal bladder and urinary control have been obtained by plastic operations". If this inspiring result can be emulated by others a radical change will come over our concept of the ideal treatment for both epispadias without urinary control and ectopia vesicae. It would certainly seem reasonable to say that transplantation of the ureters to the bowel in epispadias should be reserved for cases in which attempts to construct the vesical neck have failed. Even in such cases, given satisfactory repair of the external parts, life wearing a "why-be-wet" apparatus may prove a longer and more acceptable one than that given by ureteral transfer. Control by an ingenious external contraption held in position in skin tunnels has been described by Ombrédanne. This gave 2-2½ hours'

Plastic operation

Transplantation of ureters

retention but called for extreme precautions against ulceration. For some years, however, transfer of the ureters to the bowel, so honourably associated in Great Britain with the names of Stiles, Grey Turner and Nitch, will no doubt continue to be practised for the more serious and crippling condition, ectopia vesicae.

Technique of Young's operation.—Only the principal points of this treatment will be given.

(1) Wide exposure of the affected parts.

(2) Sufficient and controlled excision of excessive mucosa in bladder neck and posterior urethral regions. It is important to make the lumen small enough. If it is too small, it can be dilated. if it is too large, the operation will fail to give control.

(3) Careful suture of the halves of the defective internal sphincter over the reconstructed vesical orifice.

(4) Diversion of urine by suprapubic bladder drainage until operation for reconstruction of penile urethra has been performed.

For details of Young's operative technique and for a description of his operation on the case of ectopia vesicae, readers should consult his original papers.

(*b*) *Transplantation of ureters into bowel*

Grey Turner (1943), who has had an unusually wide experience of this procedure, considers the optimal age to be between 4 and 6 years but wisely points out that general condition, rather than age, is the best criterion of a child's fitness for the operation. It should not be carried out, of course, before faecal control is established. Having for many years advocated the transplantation of one ureter at a time, he now thinks that simplification of technique and increased knowledge of after-care justify simultaneous transplantation. In children, he thinks the hazards of a second anaesthetic may balance the slight extra risk of double transplantation.

Condition as criterion

Simultaneous transfer

(*c*) *Repair after ureteral transplantation*

This repair may be carried out as soon as the patient has recovered completely from his previous operations. The surgeon should avoid thinking of it as something of a minor or trifling character for it often proves a formidable undertaking associated with considerable haemorrhage and shock.

Formidable undertaking

A triangle of bladder mucosa, base downwards, is turned forwards to take part, in the male subject, in the urethral reconstruction with the idea of preserving the function of the ejaculatory ducts. In the female, a similar flap assists in the formation of the roof of the vaginal vestibule. The remainder of the bladder mucosa is very carefully dissected away and the bladder muscle is invaginated by catgut sutures: this helps in the obliteration of the deep cavity in the lower part of the wound. The removal of mucosa is greatly facilitated by wide submucous infiltration of local anaesthetic solution: this controls haemorrhage and diminishes the risk of opening the peritoneal cavity.

Removal of mucosa

The skin adjoining the now considerable defect is widely undermined on both sides and on a plane immediately superficial to the deep fascia. Flaps of fascia from the rectus sheaths are infolded and overlapped. The rectus

lines and protecting these in the immediate post-operation period against the effects of coughing or vomiting.

Finally, if there remains any weakness of the abdominal wall when healing has occurred, a well-fitting corset or belt should be provided.

6. POST-OPERATIVE ERECTIONS

Post-operative discomfort can be reduced and strain on suture lines can be lessened by the administration of oestrogenic hormone to prevent erections as recommended by Vermooten (1947) and Price and Penna (1948). In all our recent work, the equivalent of 4 milligrams of stilboestrol per day has been given to our younger patients and 6 milligrams per day to adults. Medication should begin 3 days before operation and continue until the suture lines are healed. The stilboestrol has been given in the form of Ovendosyn, a proprietary preparation in which the stilboestrol is dispensed with calcium phosphate in order to prevent the nausea sometimes produced by stilboestrol alone. *Stilboestrol*

This regimen has proved much more reliable in the prevention of erections than did our former use of bromides. No ill effects, such as the breast enlargement reported by urologists using stilboestrol in the treatment of prostatic neoplasms, have been encountered.

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[References to other titles are given under Urethra and Bladder: Congenital Malformations in the Index Volume.]

URETHRA—NEW GROWTHS AND STRICTURE

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1. NEW GROWTHS OF THE PENIS AND URETHRA

(1) Penis

337.] Growths of the penis include neoplasms arising from the shaft and coverings of the penis, excluding those originating in the urethra. *Definition*

(a) *Benign tumours*

Benign tumours are rare and unimportant, with the exception of the venereal wart, which is a papilloma of contagious origin. Other benign tumours which have been recorded are adenoma, fibroma, fibromyoma and angioma.

(b) *Malignant tumours*

Malignant tumours are usually carcinomatous, although sarcoma has been recorded.

(i) *Aetiology.*—Squamous carcinoma or epithelioma of the penis is virtually unknown in the circumcised. Chronic irritation and syphilis are predisposing causes. Paget's disease of the skin of the penis, though rare, invariably becomes epitheliomatous. According to Dean (1935), carcinoma of the penis forms 1·25 per cent of all malignant tumours found in the male, and it may occur at an early age, although the average age is 50 years.

Incidence

Site

(ii) *Pathology.*—Epithelioma is most commonly situated on the dorsal surface of the glans, less often on the external urinary meatus and fraenum. Macroscopically the tumour is either papilliferous or ulcerating. Dean found 43 per cent of the former type and 57 per cent of the latter. The papillary type grows towards the surface and may attain a large size, forming a cauliflower tumour with an indurated pedicle. The flat type ulcerates and infiltrates deeply.

Types

Lymphatic spread

Spread usually occurs along the lymphatics and, less frequently, in the erectile tissue, owing to the barrier formed by the fascial sheath of the corpus cavernosum. The lymphatics of the skin and of the glans drain into the inguinal glands, superficial and deep, and thence to glands along the iliac vessels. Clinical glandular enlargement is often inflammatory rather than neoplastic, and is due to the associated sepsis in the growth. Barringer and Dean (1924) found glandular enlargement in 63 per cent of cases, but actual carcinomatous invasion in only 30 per cent.

(iii) *Clinical features.*—The progress of the disease is slow and, owing to the covering prepuce, the condition is not discovered as a rule until it is well established. Attention is often drawn to it by a foul-smelling, sometimes sanious, discharge and interference with micturition. Therefore it is usually necessary to slit open the prepuce to establish the diagnosis by inspection of the tumour and, if essential, by biopsy. Pain is a late feature, as are cachexia and loss of weight. Erection is often interfered with and is painful.

Discharge

(iv) *Differential diagnosis.*—Carcinoma must be distinguished from infected venereal warts or papillomas. Syphilitic lesions and leucoplakia may give rise to difficulty in diagnosis. Induration of the primary tumour and stony hard enlargement of the lymph glands are strongly suggestive of carcinoma, but if there is any doubt a specimen of the tissue should be taken for biopsy.

(v) *Treatment.*—Treatment may entail surgery or radiotherapy or a combination of the two. Ideally radiotherapy is best, as it conserves the penis. This is important both for physiological and psychological reasons. If, however, there is gross sepsis, infiltration, or glandular invasion, radiotherapy is contra-indicated unless preliminary treatment by antibiotics is successful in clearing up the infection. The effect of irradiation on metastases in the

inguinal glands is debatable, but is more satisfactory in that it is less mutilating than surgery and, if ineffectual, it does not preclude subsequent surgical removal.

Surgery Surgery comprises partial and complete amputation of the penis with or without removal of the inguinal glands. As the tumour is late in spreading into the erectile tissue of the shaft of the penis, partial amputation is justifiable and, if properly carried out, leaves the individual with a stump which makes micturition possible without lowering of the trousers. Complete amputation is a mutilating procedure and is better combined with emasculation.

Excision of the inguinal glands Excision of the inguinal glands involves certain disadvantages The skin over the area is thin and avascular, therefore healing is slow and sloughing may occur. This is predisposed to by the collection of lymph in the wound from the divided lymphatics Wound sepsis may result in keloid scars or even in secondary haemorrhage from the main vessels.

Dean (1935) states that local recurrence is never found after partial amputation and, in view of the fact that 60 per cent are without metastasis, removal of the inguinal glands is unnecessary. He also states that the mortality of the complete operation is 20 per cent.

Excision of glands, if practised, should be delayed until some weeks after amputation, as any enlargement present may be septic and may resolve after removal of the primary focus.

Partial amputation Partial amputation should be performed with a ventral skin flap, drawing the divided corpus spongiosum through the flap. This is made possible by dividing the corpora cavernosa half an inch proximal to the division of the corpus spongiosum To avoid stricture, sutures should not be used to unite the divided urethra to the skin.

Radiotherapy Radiotherapy can be carried out with radium or x-rays. If radium needles are to be implanted into the growth, attention must be paid to the continued patency of the urethra during and immediately after treatment. Radium needles can also be used in a sheath applicator of Columbia paste. Modern x-ray therapy has replaced the use of radium in the treatment of small superficial growths. The majority of cases are best treated with a radium sheath. Secondary glands are treated with x-ray radiation.

(2) Urethra

Primary tumours of the male urethra are rare, and benign tumours particularly so.

(a) *Benign tumours*

The most important benign tumour is papilloma, of which there are two varieties. The villous papilloma is similar to that found in the bladder and is often secondary to a bladder tumour. Such papillomas are usually found in the posterior urethra. The warty type of papilloma is similar to the venereal warts found on the glans penis or prepuce and may be associated with them.

Villous papilloma

Warty papilloma

(b) *Malignant tumours*

Malignant tumours are usually carcinomatous, although a few cases of sarcoma of the corpus spongiosum have been reported.

(i) *Aetiology.*—Chronic urethritis and urethral stricture are found to be antecedent to 50 per cent of the cases of carcinoma, while urethral papilloma may undergo malignant change.

Incidence (ii) *Pathology.*—Carcinoma of the urethra occurs between the ages of 50 and 60 years as a rule. Kreutzmann and Colloff (1939) report that the number of cases recorded in the literature in 1939 was 150. Ninety per cent of cases are of squamous type, but adenocarcinoma may originate in Cowper's glands. Five such cases are reported by Uhle and Archer (1935). *Site* The most frequent site is that in which stricture most commonly occurs, namely, the bulbous urethra, but examples have been met with in all parts of the urethra.

Wildbolz describes a nodular type which reduces the calibre of the urethra, and an infiltrating type which grows away from the lumen of the urethra. Extension in the urethral mucosa may lead to other nodules at a distance. *Other involvement* Later the cavernous and peri-urethral tissues become involved, resulting in fungation and fistulae. The lymphatic glands, inguinal and iliac, are involved relatively early.

Pain and discharge (iii) *Symptoms.*—At first, difficult and painful micturition is noticed, associated with a muco-purulent or sanious urethral discharge. Later, external swelling may appear, and, if the tumour is in an accessible part, induration round the urethra can be detected. Ultimately peri-urethral sepsis and fungation are observed.

(iv) *Diagnosis.*—The condition is liable to be confused with urethral stricture, but suspicions should be aroused by the free haemorrhage on instrumentation, due to the friable growth. Pain on micturition is suggestive, *Urethroscopy* and in all cases of doubt urethroscopy should be carried out, specimens for biopsy being obtained.

An indolent peri-urethral abscess which fails to heal after adequate incision should always be viewed with suspicion. Urethral calculus may occasionally give rise to difficulty.

(v) *Treatment.*—When the growth is in the penile urethra, complete amputation and irradiation of the lymph glands may be carried out. Growths in the perineal part are unlikely to be diagnosed while still operable. Diversion of the urinary stream by suprapubic cystostomy coupled with radiotherapy may be used palliatively.

(vi) *Prognosis.*—Death is likely to supervene from urinary obstruction and infection, and, as the disease is usually detected at a late stage, metastases to lymphatic glands are often present already, though blood-borne metastases are very rare.

2. STRICTURE OF URETHRA

(1) Definition

By stricture is meant an abnormal narrowing of the urethral channel, bearing in mind that there is a considerable range of variation in the normal.

(2) Aetiology

In Great Britain stricture is far less frequently encountered than formerly. This is due to the fact that gonorrhoea, the important cause of stricture in

the past, is now treated efficiently and, as a rule, aborted in its early stages, thereby eliminating urethral ulceration. In spite of this, 90 per cent of cases of stricture encountered are of gonorrhoeal origin. *Origin*

Strictures can be listed as follows from a consideration of their causes and by placing them in order of frequency and importance.

(a) Gonorrhoeal stricture

The severity of the initial inflammation is the important factor. In the past, strong antiseptics and enthusiastic instrumentation were employed indiscriminately, thereby superimposing trauma and inadequate drainage upon an acute inflammatory area. The bulbous urethra, by its dependent position and partial occlusion by flexion of the urethra at the peno-scrotal junction, is naturally inadequately drained except during urination. Therefore, the bulb is the principal site of stricture. Stricture in the penile urethra is less frequent and is often associated with some anatomical narrowing of the meatus interfering with drainage. If penile strictures are present, bulbous strictures will be found as well. *Principal site* *Penile stricture*

(b) Traumatic strictures

A fall astride a hard object tends to crush the bulbous urethra between the object struck and the under-surface of the pelvic girdle. A fracture of the pelvis may disrupt the pelvic bony girdle and tear the bladder and prostate away from the urogenital diaphragm There are less obvious causes of urethral trauma which, unfortunately, are only too common. The passage of unduly large instruments may do serious harm. During cystoscopy, and more so during trans-urethral operation on the prostate, extreme care must be exercised not to force the urethra and, if necessary, meatotomy or perineal urethrostomy must be performed. It is well to remember that, in treating cases of urethral stricture, almost as much harm is done by over-enthusiastic and frequent dilatation as by neglect. The end-results of urethritis due to an indwelling catheter may be severe and result in multiple strictures. In the prostatic urethra, troublesome post-operative strictures may be met with following operations for the relief of prostatic obstruction. This portion of the urethra is otherwise unaffected by stricture owing to its wide bore and vascularity. *Fracture of pelvis* *Instrumentation* *Dilatation* *Post-operative stricture*

(c) Tuberculous strictures

These may be the end-result of tuberculous ulceration secondary to genital or renal tuberculosis.

(d) Congenital stricture

Congenital narrowing is usually found at the meatus. Congenital valves in the region of the verumontanum are a common cause of obstructed urination in the infant.

(e) Inflammatory congestive stricture

This term has the sanction of antiquity but is not really an example of stricture. Congestion and oedema produce narrowing of the urethral channel and these factors are usually present as adjuncts to fibrous stricture of small calibre.

(f) Spasmodic stricture

Spasmodic stricture is not a true stricture but a spasm of the sphincter. It is often superimposed on an organic stricture in the region of the bulb and may require a general anaesthetic for its abolition.

(3) Surgical anatomy

The points of importance in relation to stricture are as follows.

The meatus and the penile portion are the narrowest portions of the urethra. Urethral glands of Littré are most plentiful in the bulbous part of the anterior urethra. Stricture in the anterior urethra may lead to extravasation of urine and inflammatory exudates into the anterior compartment of the perineum and so on to the abdominal wall, whilst stricture in the posterior urethra may lead to extravasation above the urogenital diaphragm (perineal membrane) into the cave of Retzius.

Stricture of anterior urethra

(4) Pathology

Inflammatory stricture is a fibrosis occurring in infected urethral glands with associated periadenitis accentuated by insufficient drainage. In the formative stage, the scar contains a large number of elastic fibres, but these are later replaced by denser fibrous tissue. The terms "soft and hard infiltration" are sometimes used to denote these stages. Behind the stricture, the urethra becomes dilated and chronically infected. Peri-urethritis, abscess, extravasation of urine and fistulae tend to result. Chronic urinary sepsis may occur, with hypertrophy of the bladder and dilatation of the upper urinary tract. It is remarkable, however, how long the bladder can accommodate itself to the obstruction of a urethral stricture. Strictures are usually multiple but one predominates in producing symptoms. In the bulb, the scar tissue is most marked on the dorsal surface of the urethra, whilst in the penile urethra it is more prominent on the floor. By virtue of their origin, gonorrhoeal strictures usually involve only a portion of the urethra, primarily producing an eccentric stricture. Later, as a result of interstitial inflammation of the submucosa and corpus cavernosum, an annular or tunnel stricture may develop.

Formative stage

Scar tissue

Traumatic stricture, when it involves the anterior urethra, may be partial, due to incomplete rupture or total rupture, following complete severance of continuity of the mucosa. Although primarily uninfected, before long infection is superimposed.

Anterior urethra

In the prostatic urethra, the lesion is a total disruption of continuity and very dense strictures are prone to develop.

Prostatic urethra

(5) Clinical picture

Characteristically, the symptoms of impeded micturition do not exist until a considerable time after the initial lesion in the urethra. Occasionally, a chronic gleet has been noticed, with intermittent passage of threads in the urine due to associated prostatitis. The force of the urinary stream begins to fail so that progressive straining is necessary to empty the bladder. The stream is distorted or forked but, for a long time, an adequate flow can be produced. Dribbling and incontinence are sometimes noted. As a result of

a chill or alcoholic excess, acute retention of urine may develop. Hernia may occur from repeated straining.

(6) Diagnosis

The condition is largely indicated by the history. Palpation of the urethra may elicit localized thickening. The passage of an olive-headed gum-elastic bougie will give information as to the position and number of strictures present. In the first place, a size 18 Charriére bougie should be passed. If a narrow stricture is present, a filiform bougie should be used, and it may be necessary to attempt to pass this with the aid of an anterior urethroscope. This last-named instrument may give valuable information by showing up infiltrations and changes in the urethral mucosa. Urethrography, with Lipiodol, may occasionally be of great assistance.

Site of stricture

Urethrography

(7) Differential diagnosis

Prostatic hypertrophy produces difficulty in micturition exaggerated by straining, and the urine is clear. Nervous lesions such as tabes dorsalis produce dribbling and incontinence but the signs of nervous disease can be elicited.

(8) Prophylaxis

Ideally prophylaxis, by the prompt restoration of the urethra after traumatic rupture, or by the efficient cure of gonorrhoea in its early stages, should avoid stricture formation. Once stricture formation has occurred, the treatment is preferably by instrumentation but, if instrumentation is impracticable, operation followed by instrumentation.

(9) Instrumentation

Gradual dilatation aims at stretching rather than tearing the stricture. It is repeated at intervals until an adequate calibre has been achieved. Caution is necessary; a No. 18 Charriére bougie is an adequate size, and if further dilatation is obviously likely to produce tearing, it should not be attempted. Continuous dilatation is very valuable in narrow tight strictures. The principle involved is that the act of leaving a small instrument *in situ* will result in softening the stricture and, after removing it, a larger instrument can be passed when previously this was impossible.

Principle of dilatation

Repeated dilatation with force is to be condemned. For this reason, the Kollman dilator is an unsuitable instrument for the treatment of stricture.

For routine gradual dilatation, flexible gum-elastic bougies should be used up to size 14 Charriére and, above this, metal bougies. At first weekly sessions are necessary, spreading the interval as satisfactory dilatation is achieved. Six months, however, is the longest time that should be allowed to pass without instrumentation. Strict antiseptic precaution should be insisted on. The penis should be carefully cleansed and surrounded by sterile drapes. Sterile paraffin is the best lubricant but has the disadvantage of rendering instruments difficult to cleanse subsequently. A urinary antiseptic should be taken by the patient just before and after dilatation. A local anaesthetic should not be used as the essence of good treatment is not to

Antiseptic precautions

produce pain. Gum-elastic instruments are best sterilized in a formalin container and rinsed before use. If unduly stiff, they should be softened in hot lotion. Metal instruments are boiled. Clutton's or Lister's bougies are used for bulbar strictures, while straight metal bougies are indicated when the stricture is in the penile urethra. In dealing with tight strictures, a Harrison whip bougie is a most useful instrument.

Bougies

Continuous dilatation

For continuous dilatation, multiple filiforms are used. The urethra is filled with lubricated filiforms which are passed up to the face of the stricture. These are manipulated, one by one, until ultimately one slips through. This is then tied in, the others being removed. The patient urinates alongside the filiform which is removed 48 hours later. Gradual dilatation is then proceeded with in the usual manner.

Technique

The actual technique of passing metal instruments varies in detail with different surgeons. The patient should lie on a couch and the instrument is introduced into the meatus with the shaft lying parallel to the body and along the line of the inguinal ligament. As it passes along the urethra, the handle is elevated and turned towards the midline. It is then gradually depressed between the thighs. In a normal subject, a metal bougie should almost pass itself by its own weight.

Complications of instrumentation

(i) *False passage.*—An instrument should not be used with any force unless the tip is felt to be engaged in the stricture. If it is felt suddenly to slip onwards and this is followed by a grating sensation with free bleeding from the meatus, any further attempts at instrumentation should be abandoned for at least 48 hours.

(ii) *Catheter fever.*—This is caused by absorption of bacteria from a raw surface and is the result of unsuccessful or excessive dilatation. Free diuresis should be encouraged and urinary antiseptics administered.

(iii) *Extravasation of urine.*—This may follow false passage or over-dilatation. It is variable in the acuteness of its onset and in its extent, and may lead to a localized peri-urethritis and abscess.

(iv) *Retention of urine.*—Assuming the stricture has been dilated, retention is due to muscular spasm and should respond to antispasmodics and hot baths.

(v) *Chronic infection of the urinary tract.*—In cases of stricture, the upper urinary tract resists infection to a remarkable degree, probably because the bladder empties itself completely until very late in the life history of a case.

(10) Operative treatment

Operative treatment is indicated only if dilatation fails or is impossible. Thus it will be needed for: (a) impassable stricture, (b) resilient stricture, that is one that contracts rapidly following instrumentation; and (c) associated peri-urethral sepsis, acute or chronic.

The operations to be considered are: (a) diversion of the urinary stream; (b) meatotomy; (c) internal urethrotomy; (d) external urethrotomy; and (e) excision of the stricture.

(a) Diversion of urinary stream

(i) *Suprapubic puncture.*—This may be of use in acute retention from spasm if the stricture proves impassable. Emptying the over-distended bladder relieves congestion and often enables the patient to urinate. The stricture is dilated later. A fine-bore needle should be used to avoid leakage. If urinary sepsis is present, puncture should not be performed. *Relief of congestion*

(ii) *Suprapubic cystostomy.*—This is the most useful and generally applicable method. The fistula may prove extremely useful subsequently in locating the upper limit and position of the stricture. The fistula closes rapidly once the stricture has been satisfactorily dealt with. In gross perineal sepsis or extravasation, suprapubic cystotomy is the only legitimate treatment.

(iii) *Perineal urethrotomy.*—If the stricture is not too far back in the bulb perineal urethrotomy can be carried out. As an operation for acute retention, it was popularized by Cock (1866) At the present time, its principal use is as part of a planned operation for excision of a stricture. Occasionally, permanent urethrostomy may be indicated for intractable stricture in the penile or bulbous urethra, as advocated by Hamilton Russell (1915). *Principal use*

(b) Meatotomy

Occasionally, the meatus, while normal, is too small to permit of adequate dilatation of the proximal urethra. Meatal stricture may be present below or in association with stricture at a higher level. It is most important not to tear the meatus as this produces a severe stricture. Clean division is not followed by subsequent stenosis. Local anaesthesia can be used and the meatus is divided towards the fraenum so as to admit a No. 30 French bougie. The cut edges of mucosa and epithelium should be united with fine interrupted nylon sutures and an oily dressing applied.

(c) Internal urethrotomy

Internal urethrotomy is indicated for resilient annular stricture. The stricture must be passable and in the bulbous or penile urethra. Urinary sepsis is a contra-indication. The direction of section is towards the roof of the urethra. This is because the knife may pass through the whole thickness of the urethra and into the septum between the corpora cavernosa. If the *Contra-indication*



FIG 175.—Thomson Walker's modification of Maissoneuve's urethrotome.

cut were made towards the floor of the urethra, an external fistula might very easily result. In the deeper parts of the urethra, a cut in the dorsal surface is also safer. Several instruments have been devised for the operation but the best is Thomson Walker's modification of Maissoneuve's urethrotome (Fig. 175). This instrument is the shape of a curved urethral staff and has

a deep groove on its concave surface which groove terminates just after the curve commences. The edges of this groove are raised up in two crescents just at the curve. A tapered filiform guide can be screwed into the distal end of the staff. Two flat wings are attached on either side of the proximal end to allow of its being held firmly.

Technique

The patient lies on his back and the well-lubricated staff is passed, with an obturator occupying the groove. The filiform guide curls up inside the bladder. The crescents on the staff are arrested by the face of the stricture. The staff is held steadily by an assistant in the midline and at an angle of 45 degrees. A triangular knife, fixed on the end of a steel rod, is now passed along the groove in the staff up to the face of the stricture. The knife has a bevelled apex so that this portion will not cut and it also has two flanges on its base to prevent its escaping from the groove in the staff. It is now pushed home firmly and the stricture divided cleanly. A second division can be made by rotating the staff slightly and withdrawing the knife, cutting in reverse. A size 28 French bougie is now passed, followed by a 22 French rubber catheter which is tied in. The bladder is washed out, the catheter being drained and subsequently removed after 48 hours. Dilatation is carried out 10 days later.

Results.—In suitable cases, the results are good. The mortality is stated to be 1·5 per cent.

(*d*) *External urethrotomy*

This operation is indicated for impassable stricture, the only alternative, which should be tried first, being the passage of a metal bougie in a retrograde direction through the fistula and out along the urethra.

Wheelhouse's operation (Wheelhouse, 1876) is performed with the patient in the lithotomy position. A considerable tilt on the table to raise the perineum as in the Trendelenburg position is necessary. The Wheelhouse staff is passed down to the face of the stricture, with the groove facing the floor of the urethra. A median incision is made on to the groove. The edges of the incision are then retracted by tension sutures and the staff is rotated through 180 degrees. It is then withdrawn until the hook engages on the anterior end of the incision and fixes it. The face of the stricture is then examined carefully for an opening. This can usually be found with good illumination as, although the stricture is impassable, it is never impermeable. If great difficulty is experienced in finding the opening it is of assistance to pass a retrograde bougie down from the bladder. A probe-pointed director is pushed through the opening and on into the bladder. The whole length of the stricture is then divided thoroughly. A probe-pointed gorget is now introduced into the posterior urethra and bladder forming a tunnel along which a rubber catheter can easily be passed into the bladder. The catheter should be multiple-eyed and it is tied in. The perineal wound is lightly packed with flavine paraffin gauze, no attempt being made to suture it tightly. The catheter is removed 8 days later. At this stage, the patient passes urine partly through the external meatus and partly through the perineal fistula, which tends to close rapidly. At the end of 14 days, intermittent dilatation is commenced.

Passage of urine

Results.—This operation, which is relatively simple, gives good results but does not absolve the patient from the need of regular dilatation.

(e) Excision of stricture

This operation is suitable for annular stricture in the bulbous urethra. It has been practised for penile strictures but in this latter case there is grave risk of a penile fistula. When urinary sepsis is present, preliminary diversion of the urinary stream is essential. The initial steps of the operation are the same as in external urethrotomy. When the stricture is exposed, it is carefully dissected up and then resected. The ends of the urethra are then mobilized and united with interrupted sutures with the knots tied inside the lumen of the urethra. As long as the roof is re-fashioned, it is not essential to suture the floor as this regenerates rapidly. The superficial part of the wound is lightly packed. *Urinary sepsis*

(11) Results of operative treatment

Internal urethrotomy is not as severe an operation as external urethrotomy and is less time-consuming for the patient. The internal operation gives results possibly not as good as the external, although the mortality is lower—1·5 per cent as against 6 per cent. Excision of stricture is easier to describe than to perform and the proportion of suitable cases is small.

(12) Prognosis

The patient with stricture is never cured and it must be impressed upon him that regular, even if infrequent, passage of an instrument is essential to ward off serious trouble. Prognosis is relatively bad if gross urinary sepsis has occurred before treatment is initiated or if it persists in spite of treatment.

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[References to other titles are given under Urethra—New Growths and Stricture, in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol 12, p 386.]

URINARY ANTISEPTICS

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1. INTRODUCTION

338.] The treatment of urinary tract infections has partaken fully of the benefits conferred by recent studies of antiseptics and chemotherapeutic agents. Until early in the third decade of this century drug treatment was limited in scope, and often ineffective, although had it been directed on less haphazard lines, one antiseptic then in use might much more often have achieved success. Today, it is no exaggeration to say that, in the absence of lesions other than those produced by the infection itself, any micro-organism, except the tubercle bacillus, can regularly be eliminated from the urinary tract. This remarkable transformation has been due to a series of discoveries, starting with the ketogenic diet and proceeding through the introduction of the sulphonamides to that of the antibiotics.

2. PRINCIPLES OF TREATMENT

Laboratory investigation of urine

No rule-of-thumb method can be depended on to cure urinary tract infection. [illegible] essential to know the cause or causes of it; the skilled laboratory investi- [illegible] essential. [illegible] film

of the deposit as well as cultivation, since this alone may reveal that more than one micro-organism is present, although only one species may appear in a culture made in the ordinary way. The reaction of the urine should be observed, and if this is consistently alkaline, it is necessary to know whether this is due to the decomposition of urea with the formation of ammonia. In some cases it may be advisable to test the sensitivity of the bacteria found to the drug which it is proposed to use. Another cardinal principle is that the underlying cause, if any, must also be treated. In the presence of calculi, or of obstruction of any kind, the infection may not respond to treatment, or if it does so, is likely to recur.

Reaction

Sensitivity test

Importance of underlying cause

3. EXPERIMENTAL STUDY

Urinary antiseptics occupy a unique position from the point of view of laboratory tests, since the medium itself in which they are excreted and expected to act can be used as the experimental material. Normal urine is an excellent culture medium; a urinary antiseptic, if it is to be effective, should convert the urine from a fluid in which bacteria multiply from scores to millions overnight to one in which they are killed. It is therefore possible to judge the potential efficacy of a drug by administering it to a normal subject: his urine is collected over a 24-hour period, sterilized by filtration, adjusted to a required *p*H, if necessary, and portions of the urine are inoculated with bacteria of different species and maintained at body temperature, quantitative cultures being made at intervals to determine the rate of growth or of death. This method was employed by Garrod (1935) in an investigation of the older urinary antiseptics, and has also been the basis of valuable studies by Helmholz, which will be quoted later. The indications afforded by this proceeding have been found to correspond closely with clinical results, and the method remains of the utmost value in deciding precisely the relative merits of different forms of treatment.

Urine as culture medium

4. INDIVIDUAL URINARY ANTISEPTICS

Of the drugs available before 1935, only hexamine (hexamethylenetetramine, Urotropine, methenamine) had any general usefulness. There is some evidence of limited therapeutic effect from acriflavine, hexyl-resorcinol and methylene blue; on the other hand, there were other drugs in use at this time which were demonstrably without effect as judged by the form of test described above.

(1) Hexamine

Hexamine itself was very commonly misused, owing to misapprehensions concerning its mode of action, and, by itself, has no antibacterial action whatever, but in an acid medium it liberates formaldehyde, to which its antiseptic action is entirely due. Fortunately this reaction proceeds slowly, otherwise it might be completed in the stomach, with undesirable effects on the gastric mucosa and none on the urinary tract. The rate of liberation of formaldehyde increases with diminishing *p*H, and is only adequate when the *p*H of the urine is 6·0 or less. It was a common practice to attempt to secure this condition by

Liberation of formaldehyde

Rate of liberation

administering acid sodium phosphate but it cannot be so secured. In order to achieve this effect it is necessary to administer an ammonium salt (chloride, phosphate or benzoate, usually the first of these); the basic radical then goes to form urea, and the acid radical exerts the effect desired. It is imperative to control hexamine treatment by daily estimations of the urinary pH, either by laboratory methods or with a convenient multiple indicator; mere litmus paper is not enough.

Control of hexamine treatment

Present indications

Hexamine has been neglected in recent years, but although it has been, perhaps rightly, supplanted by other drugs in the treatment of common infections, it still has a place in dealing with micro-organisms which are resistant to sulphonamides and antibiotics. The yeasts which sometimes infect the urine of diabetics exemplify this. So far as is known, all micro-organisms are more or less equally susceptible to its action, whereas most other drugs are selective in their effect. It has to be remembered that the action of hexamine is entirely confined to the urine, in which formaldehyde is liberated from it and, since the process of liberation is slow, it will be exerted chiefly in the bladder, to a less extent in the renal pelvis, and probably to a negligible extent in the tubular system of the kidney itself. In so far as the tissues as well as the cavity of the urinary tract are involved, hexamine must therefore be useless: it is emphatically not the drug to use, for instance, in a case of pyelonephritis. For such a purpose a chemotherapeutic agent, active in the tissues as well as in the urine, is obviously essential.

Limited action

Mandelamine

Favourable accounts have lately been given of the use of Mandelamine, a chemical compound of hexamine and mandelic acid. The indication for this drug and the conditions and effects of its use are presumably the same as for the administration of its constituents separately.

(2) The ketogenic diet

Effect on urine

Although the administration of alkalis is reputed to give symptomatic relief in the acute stage of urinary tract infections, its effect on the urine is to render it a more favourable medium for bacterial growth. In order to restrain this, the logical proceeding is to render the urine as acid as possible. Mere acidity, however, is not enough; much depends on the urinary constituents to which this acidity is due. The discovery that certain organic acids, which may occur naturally in urine, have a specific bactericidal action, began with the observation by Helmholz and Clark that the urine of epileptics undergoing treatment with a "ketogenic diet" did not decompose. This diet was then used successfully in the treatment of urinary tract infections, and it was later shown by Fuller that the constituent in "ketonurine" to which the anti-bacterial effect is mainly due is β-oxybutyric acid. Rosenheim then showed that the same effect could be produced with much less trouble, expense and discomfort by the simple administration of mandelic acid.

Use in urinary tract infection

(3) Mandelic acid

Mandelic acid is best administered in the form of ammonium mandelate; a 6-hourly dose of 2 grammes together with [illegible] of ammonium chloride

will usually reduce the pH of the urine to 5·0, which should be the aim. Daily determinations of urinary pH are essential to the proper control of this treatment. Mandelic acid is effective in all common types of infection, with one important exception to be mentioned, but has lately been restricted to sulphonamide-resistant infections, and since the advent of the antibiotics, cannot be said to have any absolute indication, although it offers a simple and inexpensive alternative to other forms of treatment, with the minor advantage over the antibiotics that no injections are required.

Contra-indication

An absolute contra-indication to this treatment is infection by an organism which decomposes urea with the formation of ammonia. Such are *Proteus vulgaris*, some strains of staphylococci, other nondescript cocci (for example, the so-called *Micrococcus ureae*), and diphtheroids. Urine in which this process is going on cannot be rendered acid, and if the effect of acidifying treatment is watched only by testing the reaction of the urine, a severe and even fatal acidosis may develop undetected.

(4) Sulphonamides

(*a*) *Mode of action*

Effect on tissues and urine

Total excretion

The sulphonamides, unlike any drug considered hitherto, are chemotherapeutic agents, acting in the tissues as well as in the urine. They can thus influence infection in the walls of the urinary tract, in the kidney parenchyma and in the prostate and other accessory glands, which may be an important advantage, although it must be recognized that a majority of infections can apparently be cured by antiseptics acting only in the urine itself. The sulphonamides are wholly excreted into the urine, the concentration there attained being far higher than that in the blood. Their action is purely bacteriostatic, and is exerted best against small bacterial populations; a very high bacterial content is unfavourable to them. The sulphonamides act best in an alkaline medium.

(*b*) *Bacterial susceptibility to sulphonamides*

Although a variety of these drugs is available, with minor differences in effect on different bacterial species, in general the range of their activity is about the same. Most coliform bacilli are susceptible to the sulphonamides, *Bacillus coli* regularly so, *B. aerogenes* and *B. proteus* usually, while atypical strains and notably *Pseudomonas pyocyanea* are often more resistant. Their action on cocci is less dependable, *Streptococcus faecalis* in particular being resistant. It is impossible to dogmatize on this subject, since susceptibility exhibits marked strain, as well as species, variation. In a doubtful or difficult case, a test of the sensitivity to different drugs of the individual strain is helpful.

(*c*) *Choice of sulphonamide*

Least soluble drugs

The choice of drug involves considerations other than its degree of antibacterial effect; these considerations include its general toxicity, liability to cause sensitization, and notably it solubility and that of its acetyl derivative in urine (Medical Research Council, 1945). The least soluble of the commonly used drugs are sulphapyridine and sulphadiazine; if either of these is given

in any considerable dose, an alkali, such as sodium bicarbonate, should also be given, solubility being greater in alkaline than in acid urine, and urinary output should be maintained at not less than 1,500 millilitres daily.

Comprehensive experiments

There is much scattered and fragmentary information about the relative susceptibility to different sulphonamide drugs of the principal bacterial species concerned in urinary infection. The most comprehensive set of experiments bearing on this question was made by Helmholz (1942), using many strains of each organism and observing their behaviour in urine containing various concentrations of each of four drugs. In the following Table these are placed in order of bacteriostatic activity, figure 1 denoting the most active, and figure 4 the least active, drugs.

	SULPHA-THIAZOLE	SULPHA-DIAZINE	SULPHA-CETAMIDE	SULPHA-PYRIDINE
B. coli - - -	1	2	4	3
B. aerogenes - -	1	2	3	4
B. proteus - - -	1	2	3	4
Ps. pyocyanea - -	1	3	2	4
Salmonellae - -	2	1	3	4
Staph. aureus - -	1	3	2	4

Sulphathiazole

It will be observed that sulphathiazole is in general the most active of these four sulphonamides, and the difference is often considerable; in my experience the concentration of sulphacetamide required to inhibit the growth of a coliform bacillus in urine is commonly 5–20 times that of sulphathiazole.

Sulphanilamide

Of two important drugs omitted from this experiment, sulphanilamide has generally a much weaker action than its successors, and has no advantage other than its high solubility;

Sulphamezathine

sulphadimethylpyrimidine (Sulphamezathine), on the other hand, is to be classed with the most active, and is the most soluble of recently introduced drugs. The only important organism omitted is *Str. faecalis*;

Streptococcus faecalis

this species is in general sulphonamide resistant, but according to Helmholz (1940) its growth is inhibited by fairly high concentrations of sulphathiazole, especially if the urine is acid, for example, pH 5·5. In treating all other infections with sulphonamides, the urine should preferably be rendered alkaline, if necessary, by giving sodium bicarbonate also.

(*d*) *Details of sulphonamide treatment*

The most generally satisfactory drug is probably Sulphamezathine; sulphathiazole is equally, or more, potent, but possibly less desirable on other grounds. A 4-hourly dose of 1 gramme by day need rarely, if ever, be exceeded; such a dose produces a concentration of over 200 milligrams per 100 millilitres in the urine, and that required to inhibit the growth in urine, at least of a small inoculum of sensitive bacteria, may be only of the order of 2 milligrams per 100 millilitres, o [illegible]

Best combination of drugs

to use a mixture of drugs; the best [illegible] Sulphamezathine and sulphadiazi[illegible] urinary obstruction, since each dru[illegible] according to Lehr (1947 and 1948), also greatly reduces the risk of toxic effects

or of sensitization; therapeutic results are also said to be better than those obtained by giving an equal dose of a single drug.

There seems to be no clear evidence in favour of the idea of withholding treatment for a few days after the onset of an acute infection in order to allow the natural defences of the body to come into action. On the other hand there is something to be said, in theory at least, for a short preliminary course of mandelic acid treatment in order at least to reduce the bacterial population of the urine to numbers on which sulphonamides can exert their full effect. In view of the fact that *in vitro* a population of over 1,000,000 per millilitre is unaffected by sulphonamides, while the numbers in infected urine may greatly exceed this, it is not easy to understand how these drugs exert their initial effect. The smaller the numbers of bacteria, the greater is this effect, whereas the effect of mandelic acid is independent of this factor (Helmholz, 1943). *Preliminary mandelic acid*

(e) *Sulphonamide prophylaxis*

If it is desirable to administer an antiseptic for a long period, say of some months—to prevent the recurrence of an infection to which a patient is subject—sulphonamides are by far the most suitable drugs for the purpose, and an exceedingly small dose may suffice. Even 0·1 gramme four times daily should give a urinary concentration of over 20 milligrams per 100 millilitres and this is often 10 or more times greater than that necessary to inhibit the growth of the organism, especially if a potent drug such as sulphathiazole is used. For prevention over short periods entailing a serious risk of infection, especially in connexion with operations of the urinary tract, doses of the order of those used for therapy may be advisable. *Dosage*

(5) Penicillin

It was first pointed out by Helmholz and Sung (1944) that certain bacteria ordinarily classed as resistant to penicillin are susceptible to the concentrations attained in the urinary tract. These greatly exceed those in the blood and tissues; about 60 per cent of the drug is excreted in the urine, and thus if 50,000 units are administered 4-hourly, the average concentration in a daily output of 1,500 millilitres will be 120 units per millilitre. The minimum concentrations found necessary to inhibit the growth of bacteria causing urinary tract infections were as given in the Table. *Excretion* *Minimum concentrations*

Bacteria	Units per Millilitre
Staph. aureus –	0·05
Str. faecalis –	3
B. proteus –	8
B. coli – –	30–60
B. aerogenes –	>60

(It is to be added that *Ps pyocyanea*, as an organism freely forming penicillinase, is even more resistant than the last-named bacillus.)

Clinical experience has confirmed that infection by *Staph. aureus*, *Str. faecalis*, and *B. proteus* can be successfully treated with penicillin. It should be

given by intramuscular injection at intervals of not more than 4 hours (unless in a slow-absorption base) in order that the renal excretion of an adequate quantity may be continuous. Fluids need not be forced during penicillin administration; if anything they should be restricted. The control of pH is unnecessary.

Prophylaxis

Penicillin has been used prophylactically in connexion with such operations as prostatectomy. It is arguable that this is bad practice from the point of view of the urinary tract itself, although it may protect other tissues against accidental infection by the pyogenic cocci. Not only is the treatment without effect on the more resistant coliform bacilli, but some of them, notably *Ps. pyocyanea*, appear to be stimulated by it to greater activity. Urinary infections by this organism sometimes develop spontaneously in patients receiving a long course of penicillin for some other condition, such as bacterial endocarditis. It is theoretically much safer to give both penicillin and a sulphonamide in these circumstances, and Prince (1946) giving 1 gramme of sulphadiazine 6-hourly, and 20,000 units of penicillin 3-hourly, for 1 day before and 5–7 days after transurethral electro-resection of the prostate, was able to discharge 17 out of 36 patients with a sterile urine, a result never achieved before.

Stimulating effect on certain bacilli

(6) Streptomycin

Advantages

The main advantage of streptomycin over penicillin, from the present point of view, is its superior activity against Gram-negative bacilli generally, including species and strains hopelessly resistant to penicillin. It has, nevertheless, an adequate activity against most staphylococci and streptococci as well; streptomycin is hence the nearest approach to a universal urinary antiseptic that we have.

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Effect on urine

(a) Administration

Actual sterility is not always achieved, nor can it be without fulfilling certain conditions. Streptomycin is much more active in an alkaline than in an acid medium; it is, therefore, imperative that the urine be rendered alkaline before treatment is begun: a 6-hourly dose of 2 grammes of sodium bicarbonate, given for 1–2 days, usually achieves this. It is as well to confirm the effect by determining the pH of the first morning specimen, which is more likely to be acid than the rest of the day's output: it should be of pH 7·0 or over. Streptomycin should be administered by intramuscular injection in 4-hourly doses of 0·5 gramme. It is certainly useless to continue this treatment for more than

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3 days; usually, 2 days suffice, and patients with long-standing infections resistant to other forms of treatment have been cured by only 3–4 such injections—that is, less than 24 hours' treatment. There is good reason for believing that the issue is settled one way or another during the first day.

(*b*) *Acquired resistance to streptomycin*

If treatment fails in a case not complicated by some unfavourable factor such as obstruction, it is always accompanied by, and evidently due to, the development of resistance to the drug by the micro-organism. This change can be rapid and extreme in degree; it has frequently been observed within 24 hours of the start of treatment, and a hundredfold increase in resistance at this stage is possible, increasing to perhaps ten thousandfold shortly after. The change is permanent; hence a second course of treatment is generally quite useless, unless the original infection has been replaced by another. In planning the use of streptomycin in a difficult case, it is well to remember that the drug will only have one chance. There is some evidence that resistant organisms are derived from a very small minority of abnormally resistant cells in the original population—a minority so small that whether any succeed in surviving at all is a matter of chance. If this is so, the results of streptomycin treatment might perhaps be improved by first reducing the population by means of some other antiseptic such as a sulphonamide

Development of resistance

Preliminary treatment often advisable

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Laboratory control necessary

Reasons for failure

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Reasons for failure

blindly, without the constant guidance only to be provided by frequent expert examinations of the urine. The other reason is the frequent coexistence of an underlying lesion to which the infection is only secondary.

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[References to other titles are given under Urinary Antiseptics in the Index Volume]

UTERUS–FIBROIDS

By C. H. G. MACAFEE, M.B., F.R.C.S., F.R.C.S.I., F.R.C.O.G.
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1. AETIOLOGY

Definition

339.] The so-called uterine fibroid is one of the commonest tumours met with in women. While referred to as "fibroid" the tumour is of muscle-tissue origin and should be referred to as a myoma or fibromyoma on account of the presence of a large proportion of fibrous tissue associated with smooth muscle fibres. The aetiology of these tumours is unknown. They occur more frequently in nulliparous patients, and their frequent association with the presence of multiple retention cysts in the ovaries has suggested the possible role of ovarian hormones as a factor in their causation. Experimental work based on this belief has not proved convincing.

2. ANATOMY

Fibroid tumours are divided into two large groups: (1) corporeal, and (2) cervical.

(1) Corporeal

Interstitial

Submucous

Subserous

The fibroids found in the body of the uterus are usually described as being interstitial, submucous or subserous. According to Meyer (1930) these tumours arise from immature muscle cells in the uterine wall, and those arising in close proximity to the endometrium grow into the uterine cavity. As the result of the uterine contractions attempting to expel the intra-uterine growth, a submucous fibroid may become polypoid and be expelled through the cervical canal, forming a fibroid polypus The subserous tumours grow towards the peritoneal cavity or between the layers of the broad ligament, may become pedunculated and may attain a very large size before attracting attention. In the presence of inflammatory changes or interference with the blood supply of a pedunculated fibroid the omentum may become adherent to the tumour. In the extreme case, the tumour may receive its main blood supply from the omentum, becoming separated from the uterus and floating freely in the peritoneal cavity attached to the omentum (parasitic tumour).

Parasitic tumour

In the majority of cases the fibroids are multiple, the uterus containing submucous, interstitial and subserous tumours. In rare cases these tumours may be found in the round ligament of the uterus.

(2) Cervical

The cervical fibroid is relatively rare but on account of its situation gives rise to technical difficulties at operation, and is liable to produce retention of urine when it fills the pelvic cavity

3. SURGICAL ANATOMY

Pseudo-capsule

A characteristic anatomical feature of these tumours is that they can be easily shelled out from the uterine wall, a pseudo-capsule of thin areolar tissue separating the tumour from the surrounding uterine muscle. The subserous tumours which grow upwards present few anatomical difficulties, but those invading the broad ligament may distort the pelvic anatomy. Those arising from the body of the uterus usually grow outwards above the level of the pelvic portion of the ureter and careful dissection, keeping close to the tumour, will usually prevent any injury to this structure. Tumours

arising low down in the body of the uterus or from the cervix may have the ureter lying on their upper surface, and unless great care is taken the ureter may be injured. Tumours arising low down on the posterior surface of the corpus may fill the pelvic cavity elevating the uterus into the abdominal cavity, compressing the urethra and causing retention of urine.

4. MORBID ANATOMY

On section, the tumour presents a white whorled appearance with areas of degeneration near the centre of the tumour. The blood supply of the tumour comes from the periphery through the pseudo-capsule. As a result of this, the blood supply of the centre of the tumour is deficient and secondary changes in the macroscopic and microscopic appearances are common. Some of these, such as hyaline, myxomatous and cystic degeneration, are relatively unimportant clinically. Other changes, such as so-called "red degeneration", calcification and sarcomatous degeneration are clinically important as they present characteristic signs and symptoms. Infection of the tumour is common in the submucous type which has become polypoid and has been extruded into the vagina. Statistical investigations would suggest that the presence of myomas, especially the submucous type, predisposes to cancer of the body of the uterus. *Blood supply* *Infection*

Associated pathological conditions

While the presence of a uterine fibroid or fibroids may be the obvious pathological condition, associated pathology is not uncommon. The pathological condition most frequently associated with fibroids is endometriosis, which may make the ideal operative treatment difficult. This is especially important when the endometriosis has involved the recto-vaginal septum, obliterating the pouch of Douglas and seriously diminishing the mobility of the uterus. *Endometriosis*

(*a*) *Cancer of the uterus*

Cancer of the uterus is frequently associated with uterine fibroids and may not be suspected. When haemorrhage occurs after the menopause in a patient with uterine fibroids, cancer of the uterine body should be taken to be the cause and a radical, not partial, operation performed. Essen-Moller (quoted by Gemmell, 1936) found an incidence of 3 per cent of malignant disease associated with fibroids and unsuspected before operation. *Radical operation*

(*b*) *Tuberculous endometritis and salpingitis*

This complication is not uncommon and may not be recognized until after microscopic examination of the specimen has been carried out.

5. CLINICAL PICTURE

The clinical picture varies with the anatomical position of the tumour. The submucous tumour and some interstitial tumours give rise to menorrhagia or persistent uterine bleeding while still small, whereas the subserous tumour may grow to a large size without producing symptoms. *Menorrhagia*

In the majority of cases, haemorrhage is the predominant symptom. In *Haemorrhage*

the early stages the patient complains of menorrhagia. Later, particularly with submucous tumours which are becoming polypoid, the haemorrhage may be intermittent or persistent, causing a severe degree of anaemia. In a series of 114 cases, uterine haemorrhage was the predominant symptom in 70 per cent of cases.

Pain

Pain is of two types (a) dysmenorrhoeic, where the uterus is attempting to expel a tumour of the submucous type, or where interstitial tumours interfere with normal uterine action; or (b) persistent, usually associated with degenerative changes, particularly necrosis (red degeneration) or an associated uterine prolapse. In the series of 114 cases quoted above, pain was the predominant symptom in 35 per cent. In some series published in the United States of America the incidence of pain as the predominant symptom is as high as 65 per cent.

Pyrexia

Pyrexia is not a common sign apart from the infection associated with sloughing of a submucous fibroid polypus, or red degeneration of an intramural or subserous tumour. It is usually present in association with sarcomatous degeneration.

Pressure symptoms

Pressure symptoms are not common. The most frequent evidence of pressure is retention of urine when the tumour fills the pelvic cavity. Digestive symptoms are not uncommon in association with large subserous tumours but they also occur as a reflex symptom with a tumour in the pelvis.

Symptoms resulting from infection and degenerative changes

(a) *Infection*

Infection of a myoma is most frequently seen in the submucous type, particularly when the tumour has been expelled into the vagina, being attached to the body of the uterus by a long narrow pedicle. The circulation of the tumour is poor and its surface is exposed to trauma and infection.

Leucorrhoeal discharge

When this occurs the main symptom will be a profuse leucorrhoeal discharge which later becomes blood-stained and offensive. General symptoms, apart from anaemia, are not common, but if the tumour obstructs the cervical canal, causing a pyometra, pyrexia is common.

(b) *Red degeneration*

Red degeneration is a type of necrosis which occurs most frequently during pregnancy, but may be seen in the non-pregnant uterus. This change is associated with acute abdominal pain in the region of the tumour, which becomes extremely tender. As a rule, there is an associated pyrexia, the degree of which varies with the size of the tumour and the area involved in necrosis.

Abdominal pain

If the patient is [illegible] The attack of p[illegible] type of degeneration occurs in about 3·5 per cent of cases.

(c) *Sarcomatous degeneration*

Sarcomatous degeneration may be suspected by the rapid increase in the size of the tumour often associated with a mild pyrexia and some loss of weight. In a series of 114 cases, the incidence of sarcomatous degeneration was 1·8 per cent, which corresponds with figures published by other writers.

Incidence

6. DIAGNOSIS

The diagnosis of uterine fibroids is usually easy as one finds the uterus irregularly enlarged with one or more discrete tumours palpable on bimanual examination. Difficulty may arise with large single fibroids, especially if they become cystic when they may be confused with either pregnancy or ovarian cysts. Difficulty in arriving at a diagnosis may also be experienced where there is a small single submucous tumour. In these cases the history will suggest the presence of a fibroid, but on examination, the uterine enlargement will be symmetrical and the diagnosis will not be confirmed until the uterine cavity is explored. Biological tests, such as the Aschheim-Zondek or Friedman test, will assist in arriving at the correct diagnosis.

Single fibroid

Biological tests

7. DIFFERENTIAL DIAGNOSIS

(1) Pregnancy

A soft myoma may be confused with a pregnancy. As a general rule in these cases, the tumour is a single fibroid rising out of the pelvis up to or above the umbilicus. The history of either regular normal periods or menorrhagia instead of amenorrhoea will usually differentiate between the two conditions. A skiagram of the abdomen will not reveal foetal parts at a stage when these should be visible were pregnancy the cause of the uterine enlargement, and the biological tests will be negative. In rare cases the diagnosis may have to be made after the abdomen is opened and the tumour exposed, when the presence of large vessels traversing the tumour will distinguish it from the physiological uterine enlargement due to pregnancy.

X-ray examination

(2) Fibroids associated with pregnancy

Difficulty only arises in the early stages of pregnancy when it is found that the uterus is larger than the period of amenorrhoea would suggest. In these cases, delay of a few weeks will permit of an accurate diagnosis.

8. INDICATIONS FOR SURGICAL INTERVENTION

It is generally agreed that any uterine fibroid causing symptoms should be removed. That there are many cases in which surgical treatment is unnecessary is recognized by the accidental discovery of fibroids on a routine examination years after the menopause and the spontaneous involution of even fairly large tumours during the puerperium If symptomless tumours are discovered on routine examination, and surgical treatment is not advised or is refused, the patient should be examined regularly. Any increase in size or occurrence of symptoms is an indication for surgical treatment.

Routine examination

9 PRE-OPERATIVE MANAGEMENT OF PATIENT

The general medical condition of the patient should be considered before operation, especially if the main symptom has been uterine haemorrhage. A blood count and haemoglobin estimation should be carried out. An operation is inadvisable if the haemoglobin is low, because of the danger of post-operative thrombosis. Pre-operative blood transfusion should be given to bring the haemoglobin up to about 70–80 per cent, which may be

Anaemia

difficult or impossible if bleeding is continuing. Under such circumstances risks have to be taken in order to stop the haemorrhage and patients have been operated upon successfully whose haemoglobin was as low as 40 per cent. Under such circumstances, of course, transfusion must be continued after the operation in order to restore the haemoglobin as rapidly as possible to a normal level.

Albuminuria

Renal infection

In the presence of albuminuria and hypertension, renal function tests are advisable. If renal function is diminished the question of x-ray therapy rather than surgery should be considered. A chronic renal infection should, if possible, be treated before operation. The patient should have at least 36 hours in bed before operation, as this allows one to note the evening temperature on at least two occasions.

10. OPERATIVE TREATMENT

As a general rule the treatment of fibroids is surgical and this can be divided into two types: (1) conservative (myomectomy), and (2) radical (hysterectomy).

(1) Myomectomy

(a) Vaginal

A submucous fibroid polypus can be removed by grasping the tumour with volsellum forceps and twisting it until the pedicle breaks. This method is safer than applying traction and cutting the base of the polypus with curved scissors (Fig 176). It is associated with little or no haemorrhage and avoids the danger that traction may invert a portion of the uterine wall which may be incised leaving a perforation with possible resulting pelvic infection.

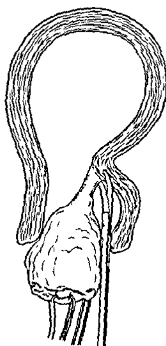


Fig 176.—Illustrating danger of applying traction to tumour and cutting pedicle with scissors

Indications

Vaginal myomectomy is most frequently necessary in women in the late thirties or early forties who have had considerable uterine haemorrhage. The removal of the fibroid polypus is necessary to stop the haemorrhage and allow the patient to be treated for her anaemia. In the majority of these cases radical surgery is necessary at a later date.

(b) Abdominal

The abdominal operation is most frequently carried out if the tumours are single or not great in number. Bonney (1946) records having removed 225 tumours, but the majority of surgeons would feel that to deal with such a number would leave a distorted and useless organ. This operation is mainly indicated in young women when it is necessary to preserve the uterus for functional and psychological reasons.

Indications

Technique.—A preliminary curettage is of value to eliminate the possibility of intra-uterine carcinoma. At the same time the cavity of the uterus can be painted with Bonney's dye (brilliant green and crystal violet). This stains the

cavity and allows the operator to recognize when, if it so happens, he enters the uterine cavity. An adequate midline incision is made to enable the uterus to be delivered into the wound.

Haemostasis

Haemostasis is important during the operation as a considerable amount of blood may be lost. Various methods of securing haemostasis have been suggested, such as Bonney's special clamp which constricts the uterine arteries; pressure on the arteries by the assistant; or a piece of rubber tubing applied round the broad ligaments compressing the arteries against the cervix.

Inspection of uterus

The uterus should be inspected carefully before making any incision. If there is a single fibroid lying on the anterior wall the decision is easy as then a curved transverse incision should be made down to and through the capsule of the fibroid near the peritoneal reflection of the utero-vesical pouch (Fig. 177). When the capsule has been incised, enucleation is usually easy. The tumour should be grasped with a volsellum and while gentle traction is applied the index finger sweeps round the periphery of the tumour which shells out of the capsule.

Excess uterine muscle

Having removed the fibroid one appears to be left with an excess of uterine muscle, but on no account should this apparent excess be removed as it can be utilized to obliterate the cavity or inverted to secure a smooth peritoneal surface.

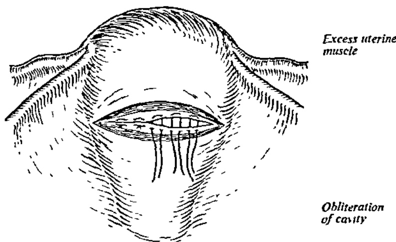


Fig 177.—Showing closure of incision for single fibroid on anterior wall.

Obliteration of cavity

Various methods of obliterating the cavity left after removal of the tumour have been described. The method commonly employed is to close the cavity by layers of interrupted sutures as shown in Fig. 178. The musculo-peritoneal edge should be sutured with a continuous inverting catgut suture. Recently Louros (1948) has described a method whereby he obliterates the cavity by inverting the redundant muscular tissue by layers of continuous catgut sutures.

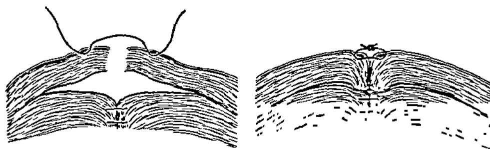


Fig 178.—Method of closure in layers with interrupted stitches

Multiple tumours

If the tumours are multiple a carefully planned incision may allow several tumours to be removed through one incision *on the anterior wall.* In order to avoid an incision on the posterior wall, it may be possible to remove a small single fibroid situated on the posterior wall by *opening the uterine* cavity and incising the capsule of the posterior tumour from the endometrial surface. When the tumours on the posterior wall are large or multiple it is wiser to make a posterior incision. In performing this operation exact haemostasis, careful closure of the cavities and complete peritonization are essential, and these requirements are particularly important when the incision, or incisions, are situated on the posterior wall, owing to the risk of adhesions between small intestine and the posterior uterine wall.

Posterior incision

Myomectomy may have to be carried out during the operation of hysterectomy. This procedure is of value when the tumour is situated in the cervix *or low on the wall of the uterus, making exposure of vital structures difficult.*

(2) Hysterectomy

Hysterectomy may be of three types: (a) subtotal, with or without removal of the adnexa; (b) total, with or without removal of the adnexa; and (c) vaginal.

(a) *Subtotal operation*

Preliminary curettage

The subtotal operation is usually employed in nulliparous women in whom the cervix is healthy. The operation should never be carried out without a preliminary curettage as otherwise some unsuspected intra-uterine or endocervical pathology, indicating removal of the cervix, may be overlooked. The risk of carcinoma developing in the cervical stump may be very low, but the writer has seen this complication occur on 6 occasions—once in the cervix of a nulliparous patient some years after the primary operation.

(b) *Total hysterectomy*

A total hysterectomy is the operation of choice in multiparous patients, especially *if the cervix is unhealthy as the result of infection or trauma.* The operation is more difficult in inexperienced hands and is associated with a greater risk of damage to the bladder or ureter than the subtotal operation.

(c) *Operative technique of abdominal hysterectomy*

Conservation of ovaries

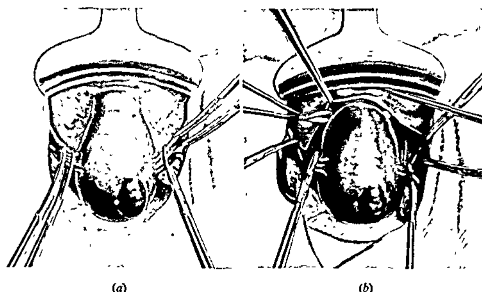
In either operation conservation of the ovaries must be considered. In many cases the patient will ask that the ovaries should be conserved, but *the operator will be unwise if he commits himself to any decision before inspecting the ovaries at operation. If the ovaries are healthy it is wise to conserve them* as their presence seems to diminish the incidence of menopausal symptoms as indicated by the presence or absence of "flushes". The presence of ovaries does not guarantee that "flushes" will not occur; in a series in which ovaries were conserved this symptom occurred in 25 per cent of the cases. As mentioned above, a preliminary curettage is advisable before a subtotal hysterectomy, but even if the decision to perform a total operation has been made it is wiser to carry out a curettage if the patient *gives a history of* irregular bleeding. In addition, the vagina should be swabbed out with

Irregular bleeding

Bonney's dye as this stains the vaginal wall and shows it up prominently during the later stages of the operation. The patient should always be catheterized at this stage.

Position The Trendelenburg position is of great advantage, but the patient should be maintained in position by the shoulder supports rather than by flexion of the knees. The latter method is liable to cause venous stasis and post-operative emboli.

Incision In most British schools the midline sub-umbilical incision is used and has the advantage of giving a good exposure and permitting a wider exploration of the abdomen if this is necessary. It is rarely necessary to carry the incision above the umbilicus except when the tumour is large. *Operative technique* The division between the recti muscles should be made with the knife rather than by blunt dissection with the fingers. When making the incision in the peritoneum it is important not to extend this too far towards the region of the symphysis as there is danger of injuring the fundus of the bladder.



(*a*) (*b*)

Fig. 179 (*a*)—The position of the clamps on the left side illustrates their application when the ovary and tube are being conserved. On the right side a clamp is placed next to the uterus and secures the round ligament, tube and a portion of the mesosalpinx. The other forceps secure the round ligament and the infundibulo-pelvic ligaments. This is the method employed when both tubes and ovaries are to be removed. (*b*) The peritoneum of the utero-vaginal pouch is being divided from the round ligament on the left to the round ligament on the right side following which the bladder is displaced downwards.

Retractors Opinions vary regarding the use of retractors, but there is no doubt that a Doyen retractor at the lower end of the wound is an advantage. The intestine should be lifted gently out of the pelvic cavity and retained in the upper abdomen with a large abdominal pack. *Inspection of pelvic organs* A careful inspection of the pelvic organs should then be made, paying particular attention to the condition of the ovaries and tubes, and noting the number and situation of the fibroids. The type of operation should have been decided before opening the abdomen, but the mobility of the uterus may be a deciding factor at this stage. If the ovaries are to be conserved and the tubes are healthy, two clamps are placed as illustrated in Fig. 179 (a). If the ovaries are diseased and it is decided that

tubes and ovaries should be removed, the lateral clamps are placed on the round ligament and on the infundibulo-pelvic ligament, taking care that they are not placed too close to the ureter as it crosses the brim of the pelvis. The peritoneum of the anterior part of the broad ligament is then divided towards the midline at the level of the reflection from the bladder to the anterior wall of the uterus (Fig. 179 (b)). With swab in swab-holder the bladder is displaced downwards from the front of the uterus and upper part of the vagina. At this stage the uterine vessels can be easily identified at each side and are clamped and divided (Fig. 180). If the operator has decided to perform a subtotal hysterectomy the body of the uterus is removed at this stage by cutting across the cervix.

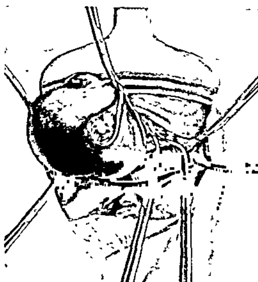


Fig. 180.—The uterine vessels are exposed and the right uterine artery and vein are secured with two clamps close to the uterine wall.

Subtotal operation

Total operation

In the total operation rather heavier clamps are now placed at either side of the uterus, keeping close to the uterine wall and taking care to avoid the inclusion of any part of the bladder. These clamps secure the cardinal or Mackenrodt's ligaments (Fig. 181). The division of these ligaments frees the uterus and should expose

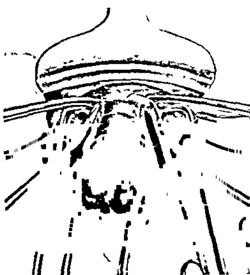


Fig. 181.—The uterine vessels on both sides have been secured and two large clamps are placed close to the side of the cervix securing the cardinal ligaments. The two volsella illustrated are applied to the vaginal fornices.

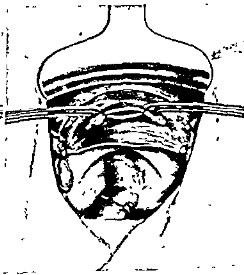
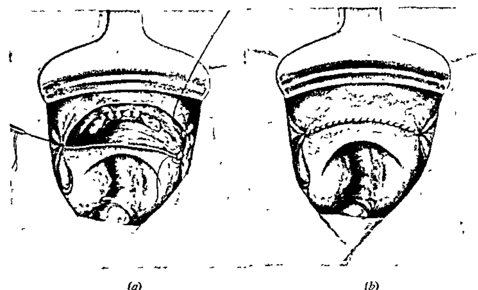


Fig. 182.—Showing the opening in the vagina following removal of the uterus with the two volsella in position.

the vaginal fornices. A volsellum forceps on each side secures the lateral fornices and the vagina is incised with a scalpel or angle scissors. If the vagina has been swabbed with Bonney's dye, as described earlier, the discoloured vaginal epithelium is easily distinguished and the incision can be continued round the fornices with ease and the uterus removed (Fig. 182).

Cervical stump

If the cervix has been retained there may be some oozing from the upper surface. This can be controlled by interrupted catgut sutures and the pelvic floor peritonized in the manner described below.



(a) (b)

FIG 183 (a).—Showing method of closing the vagina by interrupted sutures with the cardinal ligaments attached to each side, and method of applying purse-string sutures on right side and the same sutures tied on left side, (b) peritonization of pelvic floor completed by continuous suture

Vaginal vault

Opinions differ regarding the method of dealing with the vaginal vault. Some authorities leave this open, others close it with interrupted sutures (Fig. 183 (a)). In the majority of cases it can be closed, but when there is a large raw area in the pelvis, for example, when a large cervical fibroid has invaded the broad ligament, it may be advisable to leave a small opening in the centre of the vaginal vault to allow for drainage.

Peritonization of pelvic floor

In peritonizing the pelvic floor a purse-string suture (Fig. 183 (a)), secures one angle. If the ovaries have been removed this suture includes part of the posterior surface of the broad ligament, the stump of the infundibulo-pelvic ligament, the round ligament and a small portion of the anterior layer of the broad ligament. When this is tied the pedicle of the infundibulo-pelvic ligament and that of the round ligament are invaginated. A similar suture is employed on the opposite side using a long piece of catgut which, following the invagination of the pedicles, is used as a continuous suture to re-peritonize the pelvic floor (Fig. 183 (b)).

(*d*) *Vaginal hysterectomy*

The ideal case for the vaginal type of operation is the patient with a uterine fibroid or fibroids where the tumour mass is not too large and where there is a moderate or marked degree of prolapse. It is an operation which requires

more experience and skill, but when these have been attained the procedure can be carried out in a shorter time than either of the abdominal operations and with much less post-operative discomfort to the patient. It has the advantage that the uterus can be removed and the prolapse dealt with at the same time, saving the patient a second operation.

11. X-RAY TREATMENT

X-ray therapy is a method of treatment which may be used when the patient is unfit for or refuses operation. The uterus must not be much larger than an 8–10 weeks' pregnancy and, as far as possible, one should exclude the presence of an associated malignant tumour either in the uterus or ovaries

12. POST-OPERATIVE CARE

Exercise

Uncomplicated cases require little after-treatment but the patient should be encouraged to move about in bed, and to move her arms and legs at regular intervals; she should not be nursed in the Fowler position as this seems to increase the incidence of pulmonary emboli. Apart from the complications mentioned later, most patients complain of mild intestinal distension associated with "crampy pains". This can be relieved by enemas on the second day and by the giving of an aperient on the evening of the second or morning of the third day. The patient should be encouraged to get out of bed to use the commode from the second or third day.

Mild distension

Enemas and aperients

13. COMPLICATIONS

In a series of 114 cases the following were the common complications (Gemmell, 1936).

(a) *Pyrexia*

A mild degree of pyrexia lasting longer than 5 days followed 46 per cent of total hysterectomies, 50 per cent of subtotal hysterectomies and 36 per cent of vaginal hysterectomies. In most cases the temperature settled rapidly and the average stay in hospital after operation was 17·2 days.

(b) *Pulmonary complications*

Pulmonary embolus occurred in one patient who had a vaginal hysterectomy for fibroids associated with an extensive plastic operation for prolapse. The association of pulmonary embolus and vaginal hysterectomy is rare. Gemmell (1936) found that pulmonary embolus followed myomectomy in 2·8 per cent of cases.

(c) *Thrombophlebitis*

Oedema

In the series mentioned, thrombophlebitis occurred twice. In one case this was associated with considerable oedema of the right leg which was larger than the left at the end of 10 months. This complication was treated with heparin and dicoumarin.

(d) *Paralytic ileus and acute dilatation of stomach*

In the series mentioned above, these complications did not occur but in an

earlier series of 122 cases (Macafee, 1934) ileus of a marked or serious degree was not infrequent and acute gastric dilatation occurred on two occasions. The writer feels that the absence of these two complications in the recent series investigated is largely due to improved methods of anaesthesia and to the elimination of toxic drugs such as chloroform and ether.

(*e*) *Formation of granulations at vaginal vault*

This complication occurs not infrequently. It does not seem to matter whether the vaginal vault is closed at the time of operation or not, but the writer has the impression that granulations occur more frequently when chromic catgut or silk is used. The patient usually returns after 6–8 weeks complaining of a vaginal discharge which may be blood-stained. The granulation is usually polypoid and can be removed easily, using a sponge forceps to avulse it.

(*f*) *Urinary fistula*

Urinary fistula should not occur if all necessary care has been taken during operation. If the fistula is between bladder and vagina it is usually easy to deal with. If between ureter and vagina it means either transplantation of the ureter into the bladder or rectum, or removal of the kidney on the side involved (*see* p. 468).

14. RESULTS OF TREATMENT

On the whole, the surgical treatment of fibroids is most satisfactory. Of a series followed up (Gemmell, 1936), 95 per cent were either free from symptoms or considerably relieved. The most satisfactory type of case is that in which the predominant symptom is haemorrhage. The most common complaints following operation are increase in weight, and "flushes" when the ovaries have been removed. Flushes occurred in 72 per cent of such cases. Conservation of ovaries is, however, no guarantee that "flushes" will not occur The mortality rate of hysterectomy is about one per cent. In a personal series, it was 0 88 per cent.

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[References to other titles are given under Uterus—Fibroids in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 12, p. 448]

UTERUS—CARCINOMA OF THE BODY

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1. DEFINITION

340.] Carcinoma of the body of the uterus is a malignant growth originating in the endometrium of the corpus uteri, of an adenocarcinomatous nature and spreading mainly by local extension.

2. AETIOLOGY

As in the case of other malignant tumours, the exact aetiology is unknown, but the following associated conditions are regarded as factors worthy of consideration in this respect.

Age Although rare cases are encountered relatively early in life, the age of onset is usually between 50 and 60 years, about a decade later than in the case of carcinoma of the cervix (Williams, 1901; Wilson, 1917). The great majority *Menopause* of the cases therefore occur after the menopause, but, as menstruation often persists up to 50 years of age or over, cases in late menstrual life are not *Parity* uncommon. Carcinoma of the body of the uterus occurs less often in parturient women than does carcinoma of the cervix. Wilson (1917) and Cullen (1900) both found about 50 per cent of their cases nulliparous, but it is incorrect to describe this disease as essentially one of nulliparity.

Fibroids Fibromyomas of the uterus have been regarded as a predisposing factor as the two conditions are commonly found together, and various writers have put this association at from 10 to 33 per cent. The great majority of these associated fibroids are, however, small subperitoneal growths of no aetiological importance, and I have never encountered a carcinoma of the

Hyperplasia of endometrium

corpus uteri associated with a fibroid of any considerable size. Again, in Negresses, fibroids are stated to occur five times more frequently than in white women, but carcinoma of the body is relatively rare. Endometrial hyperplasia has been regarded by Taylor (1932) and others as a precancerous lesion in this region, but the supporting evidence adduced is not convincing and the ratio of occurrence of the one lesion to the other would indicate that the woman with endometrial hyperplasia is relatively safe in this respect. Again, hyperplasia is a pre-menopausal condition whereas carcinoma of the uterine body is usually post-menopausal.

According to most statistics from 5 to 10 per cent of uterine cancers occur in the body.

3. PATHOLOGY AND MORBID ANATOMY

Early appearance

The growth usually originates as a small elevation anywhere on the endometrium, but frequently towards the upper part of the uterine cavity. At [illegible] so that in a few early cases the [illegible] ·ttage. From the site of origin [illegible] ıe surface of the endometrium and (2) into the substance of the uterine musculature.

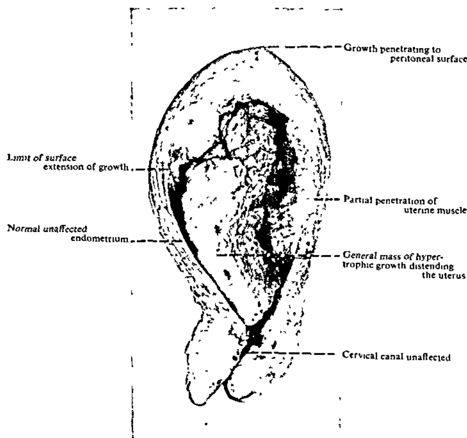


FIG. 184.—A specimen of advanced carcinoma of the body of the uterus removed by total hysterectomy. Several characteristic features in this specimen are referred to in the text.

(1) Surface spread

In time, therefore, the entire endometrium becomes involved in adenocarcinoma, *but the growth is* arrested, at least temporarily, at the isthmus uteri, which is generally regarded as an area of physiological resistance (Frankl, 1933). The cervical canal is, therefore, usually unaffected (Fig 184) except in very advanced cases, although, *if the growth is hypertrophic*, a polypoid mass may project into the cervical canal or even through the external os.

Vaginal implants

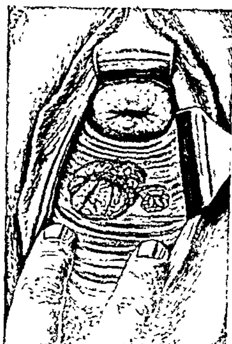


FIG. 185.—Secondary vaginal implantation in carcinoma of the body of the uterus. In this case it is on the lower posterior vaginal wall, although the anterior vaginal wall is more commonly involved (*After Cullen*)

Detached cells from the surface of the growth may become deposited in the vagina and may be recognized in smears of upper vaginal secretion. Such separated cells may become implanted on the vaginal mucosa, either on a traumatized area or on account of post-menopausal senility and lack of resistance of the tissues. A secondary vaginal implant (Fig. 185) of this kind is usually single and may be present when the patient is first seen; it may indeed constitute the first evidence of the disease. In other cases it appears at *varying intervals after an otherwise* successful hysterectomy, and in either case the prognosis is seriously affected.

The secondary vaginal implant is nearly always found on the lower part of the vagina, usually on the anterior wall and just behind the urethral orifice, with the vagina above it quite healthy.

This complication was present in 12 out of 90 consecutive cases (13·3 per cent) investigated by the writer.

(2) Uterine penetration

Penetration of the uterine wall occurs in an irregular manner and is most marked at the site of origin of the growth (Fig. *184*), but, sooner or later, the whole thickness of the uterine muscle is penetrated and the growth reaches the subperitoneal layer where it forms pale, hard and slightly elevated bosses on the outer surface of the uterus.

Prognosis

So far, therefore, the disease, although it may be advanced, is limited by the uterine musculature and the isthmus, and radical removal at this stage should carry a good prognosis.

Extensions

Further growth, however, involves penetration of the peritoneal coat of the uterus with the formation of malignant adhesions to surrounding structures, and particularly to the bladder, omentum and loops of bowel. As these three structures are all mobile, attachment to them does not

Misleading mobility

interfere with uterine mobility, a misleading clinical sign which may seem to indicate that removal can be effected, whereas laparotomy may

demonstrate attachment to one or more of these structures, a state of affairs which forbids radical operation.

Further extension is into the broad ligament and later to the wall of the bony pelvis, so that the uterus now becomes fixed by pelvic infiltration.

Tubo-ovarian involvement

Involvement of the tubes and ovaries is not common and there was no example of this complication in Cullen's series (Cullen, 1900), though Wilson (1917) found one or both ovaries involved in 7 out of 38 cases. This is probably brought about by intra-tubal extension from the uterine cavity, but Healy (1933) favours lymphatic extension. Glandular involvement is also rare and the lumbar glands on the front of the aorta and the inferior vena cava are then involved since the lymphatics from the upper part of the uterus drain directly into them. Rarely a superficial inguinal gland may be involved by extension from the fundus along the round ligament.

Glandular involvement

Naked-eye appearance

In the early stages the growth is small and symptomless but, as the condition becomes established, it ulcerates on account of infection and impaired blood supply while it tends to become hypertrophic, so that the uterine cavity becomes distended by a mass of grey, soft, caseous, haemorrhagic carcinomatous tissue (Fig. 184) which penetrates the uterine wall to varying depths. Occasionally, either by blockage or on account of weak uterine expulsive powers, the cavity becomes occupied by pent-up secretion which soon becomes purulent. This condition of pyometra was present in 4 of Wilson's 38 cases. The pus is highly infective, so that every care has to be taken to prevent it from leaking into the peritoneum during operative removal.

Pyometra

(3) Microscopic appearances

On microscopic examination the structure is that of an adenocarcinoma, and various types or stages of malignancy may be found.

Early stage

In the early stages the growth is of a papillary nature usually with the gland spaces lined by a single layer of cells (Fig. 186) so that it can easily be mistaken for simple glandular hyperplasia, especially as penetration of the muscular wall may be slight This proceeds to typical carcinoma with distended alveoli lined by multiple layers of cells, while invasion of the stroma and of the muscular wall of the uterus is now seen (Fig. 187).

Late stage

In the latest stage the malignant cells have broken all bounds, the alveolar arrangement may be lost (Fig. 188) and the uterine musculature is infiltrated by clumps of rapidly growing carcinoma cells

Rarely the growth is an epithelioma, and this change is probably brought about by metaplasia of a previous adenocarcinoma.



Fig 186—Photomicrograph of early adenocarcinoma of the body of the uterus. The growth is papillary in type with the cells mainly in one layer.

4. CLINICAL PICTURE

Irregular bleeding

The patient usually complains of irregular uterine bleeding after the menopause or in late menstrual life, and the cervix shows no sign of carcinoma. As carcinoma is a destructive disease the bleeding is irregular from the onset

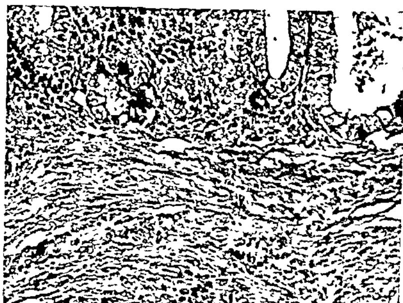


FIG 187.—Photomicrograph of a more advanced adenocarcinoma of the body of the uterus at the junction of the endometrium and the muscular coat of the uterus The carcinoma is now multi-layered or in solid columns and is penetrating the muscularis

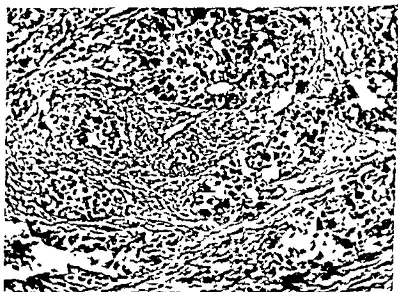


FIG. 188.—Photomicrograph of adenocarcinoma of the body of the uterus infiltrating the muscular coat.

and, if the patient should not yet have reached the menopause, it is not related to menstruation. It varies in amount and duration when the patient is first seen, but it is recurrent and tends to become progressively more marked.

Discharge, usually described as thin and watery, is due to infection of the growth and tends to occur relatively later than in carcinoma of the cervix, as the interior of the uterus is more shielded from sepsis than is the cervix. *Discharge*

Pain is not a common symptom, but, when present, indicates fixation of the uterus to the parametrium or to the pelvic wall. It is, therefore, a late symptom and usually indicates that the uterus cannot be removed. *Pain*

The general condition of the patient is good unless the condition is far advanced. She looks well and a large proportion of patients with carcinoma of the uterine body tend to be fat, a point that may complicate operative treatment. Only in the late stages do cachexia and emaciation occur, and by this time effective treatment is impossible. *General condition*

Abdominal examination is usually negative as a carcinomatous uterus very rarely constitutes a large tumour. On bimanual examination the cervix will be found to be normal or to be the seat of an old erosion. If any doubt exists on this point, examination by speculum should be carried out with investigation for friability by the insertion of a probe. Occasionally a small cervical mucous polypus may be found associated with carcinoma of the body, although the polypus itself is benign, and this indicates the importance of exploratory curettage in every suspected case. If the polypus is wrongly regarded as the cause of the bleeding and merely twisted off, the patient is left with a growing carcinoma of the uterus which has been overlooked *Local investigation* *Associated cervical polypi*

The important point about the uterus is its size in relation to the age of the patient. This, a merely bulky uterus in a woman of 30 would be of little account, whereas an organ of the same size in a woman after the menopause, along with bleeding, would be most suggestive of carcinoma; but a small uterus must not be disregarded as it may well contain an early carcinoma at the fundus. *Size of uterus*

Uterine mobility has to be carefully investigated as this usually indicates that the organ can be completely removed, although, as has been mentioned, this supposition may occasionally be shown to be wrong at subsequent laparotomy. Any infiltration in the fornices with associated uterine fixation would show the growth to be irremovable *Mobility of uterus*

5. SPECIAL AIDS TO DIAGNOSIS

The most important of these aids is diagnostic curettage, which should be carried out in every case of bleeding late in menstrual life or after the menopause *in which the cervix is not carcinomatous. The results are unpredictable,* for in one case, with only slight recent bleeding and a small uterus, carcinoma may be demonstrated, where it may not be found in another with bleeding of much longer duration. *Diagnostic curettage*

After the length of the uterine cavity is determined by the sound, dilatation to number 10 is gradually performed. This may be effected with unexpected ease, and, if the patient is nulliparous, this point is itself suspicious. During the later stages of dilatation slight bleeding is not uncommon, and, if pyometra is present, a free discharge of pus occurs. In the latter event curettage should be postponed until the uterus has been drained. *Technique of diagnostic curettage*

Curettage removes material which is plentiful in amount, yellowish-grey in colour, dull and lumpy in appearance, and these characteristics are practically diagnostic of carcinoma. If the menopause is past, carcinoma can *Characters of curetted material*

now be taken for granted, although microscopic examination of the curetted material has to be carried out. If menstruation has not yet ceased, however, the curettings have to be differentiated from those of endometrial hyperplasia which may also be abundant, but which are glistening in appearance and come away in strips, differing in both these respects from carcinomatous curettings.

Exploratory curettage as described has always to be carried out with great care and gentleness as the infiltrated uterus can be so easily perforated.

Carcinoma cells in vaginal smears

Several American workers, particularly Papanicolaou and Traut (1943), and Ayre (1946), have attempted to demonstrate early carcinoma of the body by finding malignant cells in smears of upper vaginal secretion or in intra-uterine smears, but this is a specialized investigation of questionable value which calls only for mention here.

Occasionally the presence of a low vaginal secondary growth (Fig. 185) may be the first clinical sign of carcinoma of the body of the uterus, and any bleeding complained of may come from this lesion. In such a case exploratory curettage should always be performed lest a primary growth in the fundus should be overlooked.

6. DIFFERENTIAL DIAGNOSIS

The differential diagnosis is seldom difficult, especially in the usual post-menopausal case in which the combination of blood-stained discharge and a bulky uterus is so suggestive as to indicate urgent exploratory curettage.

Fibroids

The presence of fibroids may be misleading, but these do not cause bleeding after the menopause unless associated with degeneration or sarcoma formation. Before the menopause the condition is much more likely to be

Metropathia

overlooked and regarded as metropathia haemorrhagica or due to associated fibroids. The history here may be important as a simple lesion such as metropathia produces at first excessive menstrual loss, although this may later become continual; but with a destructive lesion such as carcinoma, the uterine loss and discharge are irregular from the onset and bear no particular relationship to menstruation. Therefore, curettage should always be performed in order to exclude carcinoma before radium is inserted for metropathia.

Curettage is not usually performed before hysterectomy for fibroids, but it is extremely rare for carcinoma of the body to be missed on this account. This possibility, however, would be a justification for making total hysterectomy the operation of choice for the removal of fibroids (Spencer, 1932).

Ovarian tumours

If exploratory curettage is negative, post-menopausal bleeding may be caused by an ovarian carcinoma, usually in the early stages, or by a granulosa-cell tumour of the ovary. This indicates the importance of careful bimanual examination of the vaginal fornices in every case with this symptom.

7. INDICATIONS FOR SURGERY

Surgery is still the treatment of election in carcinoma of the uterine body, although several authorities claim almost equally good results with treatment by radium.

As in this condition the growth is confined to the uterus for a much longer period than in carcinoma of the cervix, the prospect of cure by hysterectomy is correspondingly greater, so long as this state of affairs persists. When extension beyond the uterus has occurred the possibility of removal declines steeply, and if the broad ligaments, the pelvic wall or the bladder are involved, operative removal is impracticable. If the omentum alone is involved it may be removed along with the uterus, and if only one loop of bowel is adherent to the fundus, enterectomy may be performed at the same time as hysterectomy, although this adds much to the gravity of the operation. *Hysterectomy*

All this goes to show that the main indication for surgery is limitation of the growth to the uterus, but the final decision regarding the removability of the uterus can be made only when the parts are exposed at laparotomy.

Adiposity, however, calls for special mention as a proportion of patients with carcinoma of the body tend to be fat. The policy is to remove the uterus, the broad ligaments and a cuff of the vagina, and this may be so difficult and dangerous in a fat woman with a small uterus who is perhaps not taking the anaesthetic well, that occasionally, for this reason alone, hysterectomy has to be avoided and treatment carried out by radium and by deep x-ray therapy as in the case of other irremovable growths. *Adiposity as a complication*

8. OPERATIVE TECHNIQUE

The operation of choice is total hysterectomy combined with double salpingo-oophorectomy, and the usual technique of this operation is followed. It is not necessary to perform extended removal of the pelvic cellular tissue with dissection of the ureters as in carcinoma of the cervix or to go as far down the vagina, although it is well to remove a fair vaginal cuff The main object, apart from removal of the affected organ, is to prevent recurrence, and in the pelvis this is best ensured by removal of both broad ligaments along with the uterus *Extent of operation*

Some advise suturing the cervix just before hysterectomy, together with careful vaginal douching, in an attempt to prevent vaginal implantation by fragments of the growth expressed through the os by the manipulations of hysterectomy; but equally good results are obtained by remembering to swab out the vagina immediately after operation with a gauze swab soaked in weak antiseptic. Again, on account of this possibility, any manipulation or handling of the uterus during removal should be carried out with great gentleness. *Measures to prevent recurrence*

9. RADIOTHERAPY

Radiotherapy is employed only when the disease is too advanced for surgical removal In such a case the effect can be only palliative, but even in this way it may be of great benefit in controlling distressing bleeding. The technique of application comprises diagnostic curettage followed by the insertion into the uterus of a tube containing 50 milligrams of radium. A flat box also containing 50 milligrams of radium is applied to the external os and maintained in that position by firm packing. The packing and the radium are removed after 36 hours and a further insertion of the intra-uterine tube is *Limitations* *Technique*

carried out in a week's time. The vaginal box can be omitted, and again the application is for 36 hours. After the packing and radium are removed a vaginal douche of weak antiseptic is given.

Heyman's technique and results

Certain authorities, however, elect to use radium even in early cases that would be operable. Thus, Heyman of Stockholm reported the following results in 232 cases seen between 1914 and 1930 (Heyman, 1936).

	Per cent
Absolute cure-rate with radiological treatment, including patients operated on in case of failure – – – – – – –	42 4
Relative cure-rate in clinically operable cases – – – – –	55·3
Relative cure-rate in technically operable cases – – – –	41 0
Relative cure-rate in inoperable cases – – – – – – –	25 6

His original technique was rather similar to that already described, but, later, in an attempt to obtain more even radiation of an enlarged uterus, he packed the organ with 8–12 cylinders, each 20 millimetres long and 2·8 millimetres wide with a capsule of 2 millimetres of lead and each containing 8 milligrams of radium. He aims at giving 3,000 milligram-hours in two doses, the second dose three weeks after the first.

Technique at Marie Curie Hospital

In the Marie Curie Hospital in London (Hurdon and Chambers, 1933) a central tube of radium is inserted into the cavity of the uterus, together with two short tubes extending into the cornua (Fig 189) giving an intra-uterine [illegible] the size of the uterus. Another [illegible] application and applicators are suitably screened, and each application lasts for 22 hours and is repeated a week later and again after another week's interval.

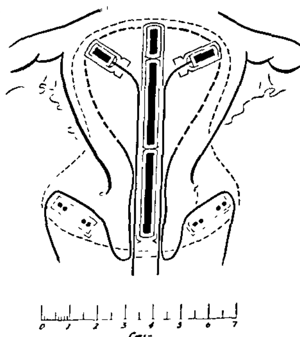


FIG. 189.—To show the technique of application of radium in the Marie Curie Hospital, London. The radium applicators are in position and the dotted line shows the probable zone of effective radiation (*After Hurdon and Chambers*)

Results

In the report of the Marie Curie Hospital for 1947, 215 cases treated in this way over five years ago with a net 5-year survival rate for all stages of 48 per cent. In stage I cases 91·7 per cent survived; in stage II cases 62·3 per cent, and in stage III, 20 per cent survived

"When cases of the very advanced stage are excluded, the net 5-year survival rate is 65 per cent." These impressive results cannot be disregarded.

10. COMBINED THERAPY

Some authorities, with a view to reducing the size and the probability of spread of the growth, insert radium into the uterus in one of the ways described, followed by operative removal in three weeks, but there is no evidence that the results are improved by these means, and in general it is better to treat carcinoma of the body of the uterus either by operation or by irradiation.

11. PROGNOSIS

Compared with carcinoma of the cervix the prognosis in carcinoma of the uterine body is relatively good, and the curability of the latter is regarded as three times that of the former lesion.

Extent of growth

The prognosis depends mainly on the extent of the growth when the patient is first seen. Thus, if it has not penetrated far and if the uterus is mobile, the prospect of cure after total hysterectomy should be fully 60 per cent. Beattie (1933) reported 35 cases of which 20 were subjected to hysterectomy with a 5-year cure rate of 48 per cent, while in 15 cases treated by radiation methods the 5-year cure rate was 18 per cent. Again, Masson and Gregg (1940), investigating 732 cases in 24 years in the Mayo Clinic, reported an immediate mortality of 5·27 per cent with a 5-year survival rate of 59 8 per cent.

If carcinomatous attachments to adjacent organs have developed the prospect of cure is almost nil. The prognosis is therefore influenced mainly by the extent of the growth at the time the uterus is investigated and not by microscopic findings.

Recurrence

Recurrence tends to involve one or other lateral pelvic wall, but, when everything in the pelvis is satisfactory, an occasional low vaginal recurrence will vitiate the whole result.

Cause of death

Death is usually brought about by cachexia from repeated haemorrhages and the absorption of toxins from the infected surfaces. Occasionally intestinal obstruction or invasion of the bladder, with infection of the urinary system, may be terminal events.

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[References to other titles are given under Uterus—Carcinoma of the body of, in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 12, p. 489.]

UTERUS–CERVIX; AND VAGINA

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1. LACERATIONS OF THE CERVIX AND CHRONIC CERVICITIS

(1) Aetiology

341.] Chronic cervicitis is an ill-defined condition of uncertain aetiology, which is characterized by hyperplasia of the cervical glands, endocervicitis, and erosion of the vaginal aspect of the cervix. Cervical erosion is not a true ulceration, but is an area surrounding the external os covered with a single layer of columnar cells, and in the sub-epithelial tissue there is a varying degree of round-cell infiltration (Fig. 190).

Cervical erosion

Two types of chronic cervicitis have been described. These are (a) the congenital erosion, which has been observed in stillborn infants and occurs in nulliparous adults; and (b) the acquired erosion, which is exceedingly common in parous women, and in most cases dates from a confinement.

Two types

Although there is no essential difference in the histology of these two types, the acquired erosion has usually been regarded as an inflammatory condition, whereas the congenital erosion has been regarded as an abnormal epithelialization of the cervix accompanied by adenomatosis of the glands.

The trauma of childbirth frequently causes small tears of the cervix, which provide a portal of entry for infection; in some cases deep laceration occurs, splitting the cervix into anterior and posterior lips, the adjacent surfaces of which become covered with columnar epithelium. This condition, ectropion of the cervix, is indistinguishable histologically from an erosion with endocervicitis.

Trauma of childbirth

Ectropion

The infective origin of chronic cervicitis is supported by the occurrence in some cases of chronic endometritis, or trigonitis, or even metastatic infection such as arthritis or irido-cyclitis, according to some authors. However, it must be admitted that the infection, if such it be, is a low-grade infection, probably due to non-haemolytic streptococci, and cannot be regarded seriously as a potential cause of puerperal sepsis or salpingitis.

It is now established that the cervix undergoes menstrual cyclical changes and even exfoliation of the mucosa after childbirth, as a result of ovarian hormonal influence. Wollner (1939) has shown that in the post-menopausal

Influence of ovarian hormones

cervix, oestrogen stimulates growth of the columnar-cell elements with hyperaemia and oedema of the stroma; progesterone stimulates squamous metaplasia, and both hormones together produce an increase of glandular tissue with parakeratosis of the squamous epithelium. Wollner suggested that the changes produced by excessive oestrogen stimulation are similar to



FIG 190.—Longitudinal section of the portio vaginalis, showing the microscopical characters of an erosion. From B to A the squamous epithelium has been replaced by an erosion continuous with the cervical endometrium, which it resembles in structure. At CEF are seen the folds of cervical endometrium known as *arbor vitae* At D the endometrium has become polypoid. (*By courtesy of Messrs J & A Churchill*)

Erosion in pregnancy

those found in chronic cervicitis, and it is significant that great attention is now being paid to cervical erosion arising in pregnancy. It seems possible therefore that oestrogen stimulation may be a more important predisposing cause of chronic cervicitis than is the trauma of childbirth, even though the condition is still held to be inflammatory in origin.

(2) Clinical picture

Leucorrhoea

The characteristic symptom of chronic cervicitis is a white discharge of mucus or muco-pus, which varies greatly in amount and does not produce much discomfort. Backache is not uncommon and occasionally there is dyspareunia. Frequency of micturition may occur from trigonitis, although pus cells are rarely found in the urine, and menorrhagia may occur if there is an associated chronic endometritis.

Relation to carcinoma

The most important aspect of chronic cervicitis is the possibility of its being a precursor of carcinoma of the cervix, which is undoubtedly more common in parous women. Cervicitis is certainly too common to be regarded as a definitely pre-cancerous lesion, but there is some evidence suggesting that adequate post-natal treatment of cervicitis reduces the risk of subsequent cancer.

Diagnosis

The diagnosis of an erosion from a carcinoma of the cervix is not difficult as a rule on careful speculum examination. An erosion presents as a reddish area surrounding the external os, but it is not friable and does not bleed when probed. Small mucous retention cysts of the cervical glands are frequently seen and are called Nabothian follicles. Endocervicitis is evidenced by excessive discharge from a rather patulous os, and in some cases small mucous polypi can be seen protruding at the os, and may cause bleeding. Whenever there is any suspicion of malignancy a piece of tissue must be removed for microscopic examination.

Excessive discharge

(3) *Treatment*

Local antiseptics

The number of methods used in the treatment of chronic cervicitis suggests that none is entirely satisfactory. It is generally agreed that local application of antiseptics is quite useless for established chronic cervicitis, although treatment in early pregnancy erosion by penicillin and sulphonamide powder has been advocated. Apart from this the most common methods of treatment are surgical procedures, cauterization, and conization of the cervix.

(*a*) *Surgical procedures*

Hysterectomy

When hysterectomy is contemplated for any associated disease of the uterine body or appendages, the presence of chronic cervicitis should certainly impel the surgeon to perform a total rather than a subtotal hysterectomy, obviating the possibility of stump carcinoma developing later.

Trachelorrhaphy and amputation of cervix

Plastic operations on the cervix such as Emmet's trachelorrhapy and Sturmdorf's amputation of the cervix have had their day. Such operations were not infrequently followed by severe secondary haemorrhage, and were reputed to cause a high abortion rate in subsequent pregnancies. Amputation of the cervix is now seldom done except as part of the Manchester operation for uterine prolapse, or very occasionally for an elongated cervix. Vaginal or abdominal hysterectomy may be considered in patients with chronic

cervicitis and endometritis, provided there is no desire for further pregnancies.

(b) Cauterization of the cervix

This is probably the most used and most satisfactory method of treatment. It can usually be performed without anaesthesia and without hospitalization in the post-natal patient. In cases of longer duration it is advisable to perform a preliminary dilatation of the cervix and to curette the endometrium if menorrhagia is present; for these patients therefore admission to hospital and anaesthesia are necessary.

Technique

Either a Paquelin cautery or an electro-cautery may be used, and Gray's heavy pattern cautery point (Fig. 191) is preferred to the fine nasal wire or flat rounded point. Longitudinal strokes of the cautery, at dull red heat, are applied to the cervical canal and carried outwards on the erosion in radiating lines, destroying the surface epithelium and draining any glandular retention cysts. Care must be taken not to cause a burn of the introitus or vaginal walls. Vaginal discharge may be somewhat increased for a week or two after cauterization and some bleeding may occur, but is rarely sufficient to cause alarm; after 4–6 weeks discharge should have ceased and the vaginal aspect of the cervix should be covered with healthy squamous epithelium. If any red areas are still present they can be retouched with the cautery.

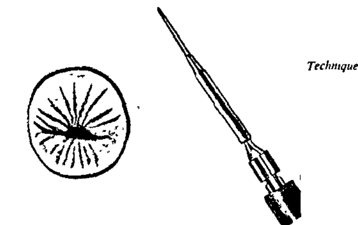


FIG. 191 —Cauterization of the cervix, showing electro-cautery point

Drainage of cysts

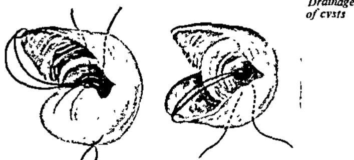


FIG. 192 —Sturmdorf sutures inserted in cervix, after conization

(c) Conization of the cervix

Technique

This operation aims at removal of the diseased portion of the cervix, by means of a high frequency alternating current. The conizer is inserted into the cervical canal, the cutting loop penetrating into the tissue up to the limits of the erosion; rotation of the instrument cores out a cone of cervical tissue. When a large cavity is left, it is advisable to cover the raw surfaces by means of Sturmdorf sutures as in circular amputation of the cervix (Fig. 192).

Although this method of treatment is becoming more popular, there is no

doubt that it suffers the disadvantages associated with surgical amputation, although perhaps to a lesser extent, and most surgeons are content with simple cauterization.

2. CERVICAL POLYPI

(1) Adenomatous polypi

Mucous polypi

The majority of adenomatous polypi arise from the epithelium lining the cervical canal, and are called mucous polypi. Such polypi are small, soft, pedunculated structures, which are pink and vascular and may be single or multiple. Usually they are associated with some degree of chronic cervicitis. Adenomatous polypi may also arise from the corporeal endometrium and may be extruded through the cervix. Larger polypi are sometimes seen, arising from the body or cervix, and may actually appear at the vaginal introitus. These usually contain a large proportion of fibrous tissue and are known as fibro-adenomatous polypi.

Fibro-adenomatous polypi

Histological structure

Adenomatous polypi consist of numerous glands lined by columnar



FIG 193 —Adenomatous polypus, showing squamous metaplasia extending into the glands (*By courtesy of W. B Saunders Co.*)

epithelium, in a highly vascular stroma of fibrous tissue. Many of the glands open on the surface, but others may form retention cysts filled with mucus. Round-cell infiltration and plasma cells are usually seen in the stroma. The covering epithelium at first consists of columnar cells, but squamous metaplasia is frequently found and may extend into the glands (Fig. 193). The squamous epithelium often shows marked hypertrophy of the basal layers, which may lead to an erroneous diagnosis of carcinoma; malignant changes may actually occur with the formation of either a squamous-cell or columnar-cell carcinoma.

Malignant change

Symptoms

The symptoms produced by adenomatous polypi are irregular bleeding, usually slight, and mucoid discharge, which is partly due to associated cervicitis.

Treatment consists in avulsion with a pair of ring forceps and cauterization of the cervix. The cervix should always be dilated and the uterus curetted in case other polypi are present. All polypi should be examined microscopically to exclude malignant disease. *Treatment*

(2) Fibroid polypi

Fibroid polypi are submucous fibromyomas which have been extruded through the cervix. The covering epithelium frequently undergoes squamous metaplasia and may ulcerate; the tumour is particularly liable to necrosis and infection.

Menorrhagia, irregular bleeding and pain may be produced, and the tumour should be removed by torsion of the pedicle. Myomectomy or hysterectomy may be necessary if other fibroids are present in the uterus. *Treatment*

(3) Malignant polypi

Carcinoma of the cervix not infrequently presents as a polypoid mass projecting from the cervix, but invasion of the cervix itself is usually evident. When on microscopical examination an adenomatous polypus is found to be malignant, it is important to determine whether the pedicle or base is involved, as this would suggest invasion or origin from the cervix itself. If the cervix is not invaded the prognosis is excellent, but radium treatment should still be carried out. *Carcinoma*

Although sarcoma is a rare uterine tumour, it is often polypoid and may be extruded through the cervix, sarcomatous change may also occur in a fibroid polypus, which should always be submitted to microscopy. Panhysterectomy should be performed if no metastases are present. *Sarcoma*

The very rare sarcoma botryoides presents as a grape-like mass of pink oedematous polypi involving the cervix and the vaginal vault. In advanced cases it may fill the vagina and infiltrate the whole pelvis, and it is said to be invariably fatal. Although it has usually been described in infants, it may occur at any age. *Grape-like sarcoma*

3. CARCINOMA OF THE CERVIX

(1) Aetiology

The uterus is more often affected by cancer than is any other organ in women, and carcinoma of the cervix is about 10 times as frequent as carcinoma of the body of the uterus. Cervical carcinoma has a wide age incidence, but the majority of cases occur in patients between the ages of 40 and 60 years. *Age incidence*

It is infrequent in nulliparous women, and therefore the trauma of childbirth and long-standing cervicitis are generally accepted as predisposing factors; furthermore it has been alleged that adequate treatment of chronic cervicitis greatly diminishes the risk of cancer. Menopausal involution and inherited susceptibility are also possible factors *Relation to childbearing*

Pemberton and Smith (1929) found that in 669 cases of carcinoma of the cervix none gave a history of previous cauterization, and of 1,408 patients in whom cauterization of the cervix had been performed not one was known to develop carcinoma.

(2) Pathology

Cervical carcinoma is usually squamous-cell in type, columnar-cell carcinoma accounting for rather less than 5 per cent of cases. It may arise in the

Site of origin

epithelium of the vaginal portion, usually near the external os, in the endocervical epithelium, or in the cervical glands (Fig. 194). However, it is impossible to correlate the site of origin with the cell type, because the epithelium of the cervix so readily undergoes metaplasia; all that can be said is that an endocervical growth is regarded as more prone to rapid spread, but of course in its early stages it is more likely to be symptomless.

Grading according to cell types

Attempts have been made to classify squamous-cell carcinoma further on the basis of cell types. Martzloff (1923) described three types of cells, the spinal cell, the transitional cell, and the spindle cell, and in Broders's classification the growth is graded according to the percentage of undifferentiated cells (Broders, 1925). In the well-differentiated type of growth most of the cells have abundant cytoplasm and large nuclei, which take only a moderately deep haematoxylin stain; epithelial pearl formation and keratinization may occur (Fig. 195). In the poorly differentiated or anaplastic type the cells are small and spindle-shaped, the nuclei are hyperchromatic with frequent mitoses, and the cytoplasm is scanty (Fig.

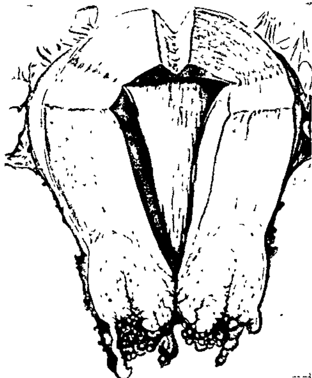


FIG. 194.—Carcinoma of the cervix. (*By courtesy of W. B. Saunders Co.*)



FIG. 195.—Well-differentiated spinal-cell type, showing an epithelial pearl. (*By courtesy of W. B. Saunders Co.*)

196) The transitional cells form an intermediate group (Fig. 197). It is *Rate of growth ratio*

The response of a growth to irradiation does not necessarily bear a direct *Response to irradiation* relationship to the degree of differentiation. The work of Glucksmann and Spear (1945) suggests the possibility of assessing this response by means of a cell-count technique, in biopsies taken from the growing edge before and during irradiation. The cell population is counted in four categories: resting (potential dividing "stock" cells), mitotic, differentiating (mainly keratinizing and parakeratotic cells), and degenerating cells. In unfavourable cases the cell count before and after the first radium dose is approximately the same and actively growing tumour tissue is still present. The rate of growth may be considerably retarded and a good clinical response may be obtained at first, but local recurrence is inevitable. *Cell count in unfavourable cases*



FIG 196.—Anaplastic spindle-cell type, showing frequent mitoses (*By courtesy of W B. Saunders Co*)

In favourable cases viable cells (resting and mitotic) are replaced by non-viable (differentiating and degenerating) cells, or there is a marked increase in abnormal mitotic and degenerating cells. A great reduction in the percentage of viable cells is considered a partial response and is interpreted as ultimately unfavourable. A favourable prognosis will of course apply only for the fully treated primary growth, and not for involved lymph glands if they are beyond the range of effective irradiation. *Cell count in favourable cases*

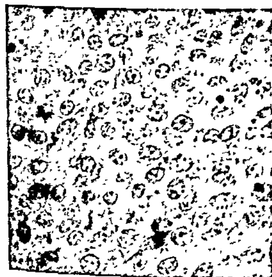


FIG. 197.—Intermediate transitional-cell type (*By courtesy of W. B Saunders Co.*)

Contrary to accepted views these workers found a favourable final response more often in the differentiated than in the anaplastic types. Columnar-cell carcinoma, although well differentiated as a rule, shows poor response to irradiation.

(a) *Spread of carcinoma of the cervix*

This may occur in the three ways described overleaf.

(i) *Direct infiltration of surrounding tissues and permeation of lymphatic channels in and around the cervix.*—Extension occurs to the vaginal vault and down the vaginal walls, where isolated areas of growth are sometimes found as a result of lymphatic permeation; to the parametric tissue on either side of the cervix, where the ureters may be involved by growth or fibrosis; to the trigone of the bladder anteriorly; along the utero-sacral ligaments or posterior vaginal wall to the rectum; to the body of the uterus. (This upward spread is rare, and when both body and cervix are involved it may be difficult to determine the site of origin.) Very occasionally secondary deposits are found in the ovaries.

(ii) *Lymphatic emboli to the related lymph glands.*—Lymphatic channels from the cervix pass to an inconstant gland in the parametrium, and then to the obturator and iliac glands; occasionally the pararectal glands are involved and in late cases the para-aortic or lumbar glands become affected.

Relation to primary growth

Lymph-gland involvement can only be determined at operation and by microscopic section, because glands may be enlarged from sepsis and quite small glands may contain microscopic foci of malignant cells In late cases fixation of gland masses to the iliac vessels or to the pelvic wall makes removal difficult or impossible. Lymph-gland metastases are not dependent on the extent of the primary cervical lesion. They are found in about 40 per cent of early operable cases, and are absent in about a third of advanced inoperable cases.

Remote metastases

(iii) *Blood-stream metastases.*—Blood-stream metastases are comparatively rare and are usually late manifestations. They may occur in liver or spleen, lungs, skeletal system or in the brain.

(*b*) *Classification into stages*

For statistical purposes the international classification of carcinoma of the cervix into stages has been adopted in most clinics for comparison of therapeutic results, but it is based on individual clinical assessment, which is often variable, and in most cases lymph-gland involvement is undetermined.

Limited growth

Stage I. The growth is strictly limited to the cervix in the first stage; the uterus is mobile.

Spread into fornices

Stage II. At this stage the lesion is spreading into one or more fornices, with or without infiltration of the parametrium adjacent to the uterus, the uterus retaining some degree of mobility.

Nodular infiltration of parametria

Stage III. This stage includes (a) nodular infiltration of the parametria on one or both sides, extending to the wall of the pelvis, with limited mobility of the uterus or massive infiltration of one parametrium with fixation of the uterus; (b) more or less superficial infiltration of a large part of the vagina, with a mobile uterus; (c) isolated metastases in the pelvic glands with a relatively small primary growth, and (d) isolated metastases in the lower part of the vagina.

Metastases in pelvic glands

Massive infiltration of parametria

Stage IV. The fourth stage includes (a) cases with massive infiltration of both parametria extending to the walls of the pelvis; (b) carcinoma involving the bladder or rectum; (c) infiltration of the whole vagina, or infiltration along its whole length with fixation of the primary growth; and (d) remote metastases.

(3) Clinical picture

(a) Symptoms

The earliest stages of cervical carcinoma, before necrosis and ulceration occur, are symptomless, and a number of cases are quite advanced when first seen. Irregular bleeding is usually the earliest symptom, although it is not usually severe at first; it may be produced by intercourse. Not infrequently there is also a thin watery discharge which is blood-stained at times. When ulceration has occurred there is frequent or severe haemorrhage, with a markedly offensive discharge. Pain is never an early symptom, and generally indicates parametric infiltration; it is felt in the back or may affect the sciatic distribution in one or other leg, and it is often worse at night. *Irregular bleeding* *Pain*

(b) Signs

The physical signs on vaginal examination are somewhat variable. In the early stages a small indurated area or shallow ulcer may be felt or seen near the external os; more often there is either a fungating mass of growth attached to the cervix, or the cervix may be replaced by a deep ragged ulcer crater. With an endocervical carcinoma the whole cervix may be enlarged, but with little or no ulceration of the vaginal portion at first. The most important diagnostic points are friability of the growth and a tendency to bleed on examination.

Evidence of extension of the growth should be sought for on vaginal examination by noting the extent of induration or ulceration of the vaginal walls, and by testing the mobility of the cervix. Parametric infiltration causes relative fixation and thickening may be felt on one or both sides of the cervix. The extent of parametric infiltration and involvement of the utero-sacral ligaments is best felt on rectal examination, and so is the barrel-shaped enlargement of the cervix characteristic of an endocervical growth. *Mobility* *Rectal examination*

A bimanual examination is necessary to exclude enlargement of the uterus or appendages, and it must be remembered that pyometra is a common accompaniment of carcinoma of the cervix. *Pyometra*

Cystoscopic examination is essential to exclude involvement of the trigone, the earliest sign being bullous oedema and hyperaemia. *Cystoscopy*

In the late stages urinary or rectal fistulae may occur, and usually there are signs of cachexia, marked anaemia often being present. Salpingitis and pelvic peritonitis may occur in the terminal stages, and not infrequently hydronephrosis or pyonephroses results from ureteric involvement. Femoral thrombosis sometimes occurs and may be followed by pulmonary embolism. *Late signs*

(4) Diagnostic procedures

Biopsy is essential in all cases not only to confirm the diagnosis, but also to determine the cell type and malignancy of the particular growth. Repeated biopsies using the cell-count technique are advisable to determine the response to irradiation. In taking the specimen for biopsy a scalpel or punch forceps should be used rather than diathermy, which spoils the tissue; it is necessary to take tissue from the growing edge rather than from the necrotic centre of the growth. *Biopsy*

Attempts have been made to obtain earlier diagnosis in carcinoma of the cervix, first by education of the public and by teaching medical practitioners

the necessity for careful examination in all cases of irregular vaginal bleeding, secondly, by *routine* examinations. Direct examination of the cervix by means of a colposcope has been advocated by Hinselmann (1927), but must be followed by biopsy. *Schiller's iodine test* (Schiller, 1933) consists in painting the cervix with *Lugol's solution* (iodine 1 part, potassium iodide 2 parts, water 300 parts) which stains the normal squamous epithelium of the cervix deep brown, whilst cancerous epithelium is unstained. It is far less conclusive than microscopy and is now little used. It is probable that the vaginal smear technique of Papanicolaou may prove to be a most valuable method of early diagnosis (Papanicolaou and Traut, 1943). (*See* Uterus—Carcinoma of the body, p. 446.)

Colposcopy

Schiller's test

Vaginal smear

(5) Assessment of suitable treatment

Before making a final decision as to the methods to be employed in the treatment of a particular case, the following factors must be considered.

(a) General condition of the patient

Advanced age, concomitant disease or marked adiposity are unfavourable to surgery, even though the growth is operable. On the other hand, pelvic tumours or pelvic sepsis cause a bias in favour of surgery.

(b) Stage of the growth

All cases in Stages I and II can be regarded as operable, and some in Stage III, but it must be appreciated that staging before operation is a matter of clinical impression, and gland involvement cannot be assessed. Some cases are therefore found to be inoperable when the abdomen is opened, and radical surgery has to be abandoned. Although Bonney (1941) was able to achieve a 53 per cent 5-year cure rate where glands were not involved, this was reduced to 22 per cent when lymph glands were invaded.

Cure rate and lymph gland involvement

(c) Histological type of growth

The degree of differentiation, and of still greater importance the cytological response to irradiation, are factors which must receive greater attention.

(6) Methods of treatment

Carcinoma of the cervix may be treated by radium or by radical surgery, or by some combination of these two methods, and deep x-ray therapy is often used in addition. It is unfortunate that there has been such sharp division of opinion as to the relative merits of radical surgery and irradiation, and so little co-operation between radiotherapists and surgeons.

Bonney (1941) was able to operate on 55 per cent of cases seen, and obtained a 40–43 per cent 5-year survival rate. The operative mortality in his 500 cases was 14 per cent; this was a wonderful achievement, but with the aid of chemotherapy, blood transfusions and improved methods of anaesthesia, the operative mortality today is about 5 per cent in the hands of experienced surgeons. The radical vaginal operation of Schauta has not become popular with British surgeons because it fails to eradicate lymph glands, and therefore offers little hope of improving end-results.

Bonney's operation results

Schauta's operation

Radium treatment has the advantage of a low primary mortality, and in Stages I and II the 5-year survival rate has been between 40 and 60 per cent with a 20–30 5-year percentage in Stage III. Recent figures show a further improvement (*see* Table) and there has been a swing of the pendulum towards

Radium results

radiotherapy. It must be accepted that radiotherapy now offers a better chance of cure with a lower primary mortality in Stages I and II than does radical surgery, and offers a not inconsiderable hope of cure when radical surgery is impossible.

TABLE

RESULTS OF RADIUM TREATMENT FOR CARCINOMA OF THE CERVIX

Institution	Stage I		Stage II		Stage III		Stage IV		All Stages	
	No of cases	% cured	No. of cases	% cured	No. of cases	% cured	No. of cases	% cured	No of cases	% cured
Marie Curie Hospital (London) 1945 Report	88	82 7	377	60 0	734	30 4	211	7 7	1,410	38 0
Manchester—1945 Report (1934–38) –	48	65 0	292	42·0	241	27 0	245	6 0	826	28 0
Toronto—1947 Report (1929–41) – –	80	80 0	246	53 6	289	31 8	141	9 2	756	39 8

Glucksmann and Way (1948) have shown that there is still a definite place for the employment of surgery, if the reliability of the Glucksmann-Spear cell-count technique is accepted. Using the 3-dose Stockholm technique they advocate the following. *Place for radical surgery*

(a) Radical surgery 6 weeks after the second dose (the third being omitted to avoid massive pelvic necrosis), in suitable cases when the radium response is unfavourable. Inoperable cases are given the full Stockholm technique.

(b) Dissection of the pelvic glands if radium response is favourable, 2 weeks after the full Stockholm technique. In most clinics deep x-ray therapy is preferred to gland dissection, but there is no evidence to show that it can overcome gland involvement. *Dissection of the pelvic glands*

It is unfortunate that cases showing an unfavourable response to radium are often anaplastic and advanced, with a high incidence of gland involvement, but this should stimulate the ingenuity and skill of surgeons who have the courage to tackle difficult problems. Radical surgery should not be lightly undertaken by surgeons without special experience, and whenever possible the treatment of carcinoma of the cervix, whether by irradiation or by surgery, should be in the hands of surgeons experienced in these methods.

It must also be recognized that there is a group of patients who are beyond hope of cure by any method, and for them palliative treatment is necessary, and this must include procedures such as cordotomy for the relief of intractable pain. *Palliative surgery*

(7) Radium treatment

The object of radiotherapy is to administer a lethal dose of *gamma* rays to all cancer cells in the immediate vicinity of the cervix, without producing tissue necrosis. The latter may be caused by inadequate screening of the radium or by excessive dosage, whether by radium, deep x-rays or the combined effect of both. Tissue necrosis invites sepsis and may cause urinary

Dangers of tissue necrosis

or rectal fistulae; furthermore it appears that cancer may continue to grow and spread if tissue necrosis occurs from overdosage.

Stockholm technique

In the Stockholm technique the cervix is dilated under anaesthesia, and 40 milligrams of radium in a metal container are inserted into the uterine cavity. Two metal boxes or ovoids, each containing 35 milligrams of radium, are then inserted into each lateral fornix, and held in position by careful packing of the vagina. The packing should be inserted so as to protect the rectum as far as possible. A self-retaining catheter is then inserted, and a pad and T-bandage applied. Skiagrams may be taken to ensure that the radium is retained in position. The radium is removed after 19–22 hours, and two further applications are made after intervals of 1 and 2 weeks.

Paris technique

In the Paris technique a smaller dose is used for one prolonged treatment. The uterine tube, containing 33·33 milligrams of radium, is left in for 5 days, and the vaginal applicators, containing altogether 33·33 milligrams of radium, are re-inserted every day after douching.

Various modifications of these techniques have been tried, both as to dosage and applicators, to ensure accurate dosage and to minimize the risks of tissue necrosis.

(8) Radical surgery

Scope of operation

The modification of Wertheim's hysterectomy by Berkeley and Bonney (1947) aims at the removal of the uterus and its appendages, together with a large part of the vagina, the parametric tissue on either side of the cervix, and the related pelvic lymphatic glands; if these are involved the para-aortic glands should also be removed.

The operation calls for skill and experience, and should be preceded by thorough investigation and blood transfusion if necessary; intravenous blood or plasma may also be needed during the operation. Local sepsis should be controlled as far as possible, and operation should be deferred for 6 weeks after radium therapy. Spinal anaesthesia followed by gas, oxygen and ether has been advocated, but the modern anaesthetist favours Pentothal, curare and cyclopropane.

Anaesthetic

Technique

After exposure of the pelvic organs the ovario-pelvic folds and round ligaments are ligated and divided. The utero-vesical fold of peritoneum is divided and the bladder is separated from the cervix and upper vagina. If the bladder is invaded by growth the operation may have to be abandoned at this stage. The origin of the uterine artery is found and ligated and the ureter is identified on each side. The terminal part of the ureter lies in parametric tissue and must be carefully freed (Fig. 198). If it is injured or involved in growth it must be divided and transplanted into the bladder. The peritoneum of the pouch of Douglas is then divided and the rectum is dissected away from the vagina. The parametrium and lateral cervical ligaments are divided as near as possible to the side walls of the pelvis, and the utero-sacral ligaments are then clamped and divided near the rectum (Fig. 199). The ureters and bladder are retracted out of the way and Bonney's clamp is applied to the vagina as low down as possible. The vagina is then divided below the clamp, so that the growth is removed enclosed in a bag of vagina. Lymphatic glands in the obturator fossae are then removed and all fat and glandular tissue removed from the iliac vessels; during this

Bonney's clamp

dissection the obliterated hypogastric artery is removed, and its common origin with the uterine artery from the internal iliac artery must be ligated. The vagina need not be sutured and this will allow for drainage from the pelvis. The pelvic floor must be peritonized, and the abdomen is then closed.

Post-operative care

Post-operative treatment should include bladder drainage with a self-retaining catheter for 5–6 days, and chemotherapy if sepsis is present.

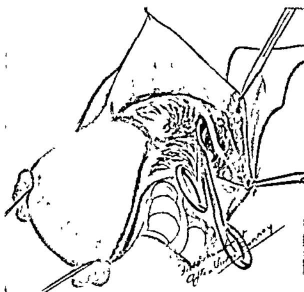


FIG 198 —Freeing the ureter (*After Bonney.*)

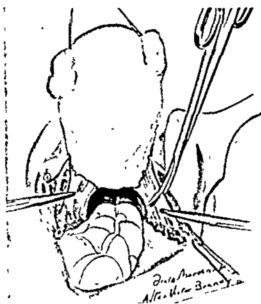


FIG 199 —Dividing the utero-sacral ligaments (*After Bonney*)

4. CONGENITAL ABNORMALITIES OF THE VAGINA

(1) Absence of the vagina

Construction of artificial vagina

Complete absence of the vagina is a rare condition, usually associated with absence or rudimentary formation of the uterus. Reconstruction of the vagina by using a loop of small bowel has been superseded by the plastic operation of Banister and MacIndoe (1938). In this operation a transverse incision is made at the junction of the vulva and the perineum, and by blunt dissection the urethra and bladder are separated from the perineal body and the rectum. A vulcanite mould covered with Thiersch graft is inserted into this cavity, and the wound closed over it. The mould is removed after 3–4 months and an introitus is formed.

(2) Haematocolpos

Imperforate hymen

Haematometra

Incomplete canalization of the lower end of the fused Müllerian ducts results in closure of the vagina by a transverse membrane, which is usually situated in the lower third and is often called an imperforate hymen. Retention of the menstrual lochia causes marked distension of the vagina with thick tarry blood, and this is known as a haematocolpos. Haematometra occasionally occurs with an untreated haematocolpos, or with congenital atresia of the cervical canal.

Cryptomenorrhoea

Hidden menstruation or cryptomenorrhoea produces increasing discomfort or pain at monthly intervals, and within a year or two of puberty the haematocolpos may be large enough to cause frequency of micturition and finally retention of urine, owing to elongation of the urethra.

Diagnosis

Treatment

The diagnosis of haematocolpos is clear when a tense bulging membrane is seen at the vaginal introitus, and the condition can be relieved by a cruciform incision to allow the fluid to drain away. Strict asepsis is necessary to prevent ascending infection, and a bimanual examination must be made to exclude haematometra. If this is suspected, conservative treatment is recommended.

Absence of the lower part of the vagina, with haematocolpos of the upper third, must be dealt with by blunt dissection until the haematocolpos is reached. After evacuation of the fluid, the vaginal walls may be drawn down and stitched to the introitus.

(3) Septate vagina

Double vagina

Incomplete fusion of the lower end of the Müllerian ducts results in a double vagina; the median septum may be incomplete above or below. This abnormality may be associated with uterus didelphys or a bicornuate uterus, in which case the cervix is also duplicated. Excision of the vaginal septum may be necessary if it interferes with intercourse.

5. VAGINITIS AND ULCERATION OF THE VAGINA

(1) Aetiology

Vaginal acidity

The reaction of the vagina in the childbearing period of life is acid, the normal pH being between 3·8 and 4·4. Lactic acid is produced from glycogen in the vaginal epithelium, and *Doderlein's bacillus is the predominant* organism. This high acidity evidently prevents the growth of harmful organisms, but nevertheless vaginitis is a common condition, and is associated with diminished vaginal acidity.

(a) Trichomoniasis

Trichomonas vaginalis

Infection of the vagina with the parasite *Trichomonas vaginalis* probably occurs from more or less intimate contact with infected persons. The parasite lives on glycogen and flourishes in a slightly acid medium, the most favourable pH being around 5 3.

(b) Vaginal thrush

Oidium albicans

Vaginal thrush is due to the *Oidium albicans*, which flourishes when the reaction is around pH 4·8. Glycogen is essential for its growth, and infection

is likely to occur in patients with diabetes mellitus or in pregnant women with glycosuria.

(c) Vulvo-vaginitis in children

Vaginitis is rare before puberty, presumably because of the absence of glycogen in the vaginal epithelium. When it does occur it is usually bacterial and may be gonococcal in origin; such cases are highly contagious.

(d) Senile vaginitis

Senile vaginitis, occurring after the menopause, is again usually due to bacterial infection; atrophy of the vaginal epithelium and diminished glycogen content predispose to its occurrence.

(e) Ulceration of the vagina

Ulceration of the vagina may be caused by the pressure of a neglected or ill-fitting pessary; infection of a laceration produced by childbirth or other trauma; friction in the case of an untreated procidentia; radium burns; tuberculous or syphilitic infection; or malignant new growths.

(2) Clinical picture

In all cases of vaginitis there is a purulent discharge which may be offensive, and which often produces soreness of the vulva. *Vaginal discharge* Careful examination of the vagina with a speculum and a good light is essential to determine the cause, and to exclude gonorrhoea. This will be suspected if urethritis is present, *Exclusion of gonorrhoea* and pus from the urethra must be examined bacteriologically. In trichomoniasis the pus is greenish yellow in colour and contains minute bubbles of gas, small red spots are seen on the vaginal walls and sometimes on the vaginal aspect of the cervix. In thrush, thick white flakes may be seen on the vaginal wall, and when these are removed raw patches are left.

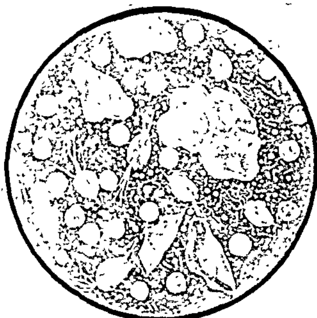


FIG. 200.—*Trichomonas vaginalis* in moist vaginal smear (*By courtesy of Messrs J. & A. Churchill*)

Vaginal washings with saline solution introduced by a pipette should be *Vaginal washings* examined in a wet film to identify the causal organisms (Fig. 200). Examination of the urine for glycosuria should never be omitted, and it is wise to note *Glycosuria* the presence of cervicitis which, if untreated, may cause a persistence of the conditions favourable to recurrence of the vaginitis.

(3) Treatment

When ulceration of the vagina is found, the cause must be discovered and

treated. Douching may be necessary if there is a copious offensive discharge, and healing will be assisted by the application of antiseptics.

Vaginitis in children

Children with vulvo-vaginitis must be isolated and if the infection is gonococcal it should be treated with sulphonamides or penicillin. Local antiseptics may be used and oestrogen pessaries may be inserted into the vagina to encourage the formation of glycogen in the epithelium. Senile vaginitis is treated similarly by local antiseptics and small doses of oestrogen; but the possibility of senile endometritis or pyometra must be borne in mind and treated if present.

Senile vaginitis

Trichomoniasis

Many forms of treatment have been advocated for trichomoniasis, and the most successful is an arsenical preparation, Stovarsol, in a carbohydrate base. One or 2 tablets should be inserted high up in the vagina every night for 2 weeks. Strict attention to hygiene, and the use of an antiseptic such as 4 per cent aqueous mercurochrome, help to eradicate the infection and to prevent recurrence. In vaginal thrush it is necessary to cleanse the vagina of exudate by means of saline swabs. One per cent aqueous gentian violet should then be applied on 2 or 3 occasions, and glycosuria must be controlled if it is present.

Vaginal thrush

6. VAGINAL FISTULAE

(1) Urinary fistulae

Types of fistula

Leakage of urine from the vagina is usually due to a vesico-vaginal fistula; more rarely the fistula is ureteric, and very occasionally both types of fistula coexist The patient is always wet, and her life is one of misery. Some patients pass urine normally as well, indicating a small vesical or perhaps a ureteric fistula; in other cases the leakage is complete. The vaginal orifice and vulva may be excoriated, and urinary infection is very liable to occur. Phosphatic encrustation may be found at the margin of the bladder opening, and in a few cases large calculi are found in the bladder or even in the vagina.

Phosphatic deposits

(*a*) *Aetiology*

The causes of urinary fistula are as follows.

(i) *Injuries received during difficult labour, either from direct laceration of the tissues or by pressure necrosis.*—This is no longer the commonest cause, and it was in the days of Marion Sims, except perhaps in countries like India or Africa, where native women do not always receive proper obstetric attention. In such places very large vesical fistulae may still be encountered.

(ii) *Injuries received during gynaecological operations.*—The bladder or ureters may be injured during a total or Wertheim's hysterectomy, more rarely during a vaginal hysterectomy or colporrhaphy; or necrosis may follow interference with the blood supply. Such fistulae are usually small and situated high in the vaginal vault.

(iii) *Malignant disease or necrosis following radium treatment.*—Fistulae may be caused by malignant disease of the cervix, vagina or urethra, or sometimes by necrosis following radium treatment of these conditions. Malignant fistulae cannot of course be repaired, and those due to radium are almost hopeless because the surrounding tissues are devitalized.

In both obstetric and gynaecological cases, the leakage of urine may

immediately follow delivery or operation, but when the fistula results from necrosis of tissue, the leakage may not be apparent for 5–12 days. *Delayed appearance of incontinence*

(*b*) *Investigation*

Thorough investigation is essential before any operative procedure is planned.

Speculum examination of the vagina is necessary to discover the site and size of the opening. A small fistula may be difficult to find until a solution of methylene blue is run into the bladder. A catheter specimen of urine should be examined for evidence of infection. Cystoscopic examination of the bladder, after packing the vagina, should be made to determine the site of the opening and its relation to the ureteric orifices. This may be impossible with large fistulae, because of the escape of urine. Very small fistulae may be discovered by injecting air into the vagina whilst doing the cystoscopy. Ureteric catheterization is of value in the diagnosis of ureteric fistulae. *Speculum investigation* *Urine examination* *Cystoscopy*

Intravenous pyelography should be carried out to determine the function of both kidneys, and to gain evidence of ureteric injury. In such cases it is essential to exclude the possibility of a double ureter or a Y-shaped ureter. *Pyelography*

(*c*) *Treatment*

Immediate treatment by catheter drainage of the bladder and by automatic suction, postural drainage, and vaginal douching, offers some hope of spontaneous closure in the case of small vesical fistulae When a fistula has been present for 6 weeks or more spontaneous closure is unlikely and surgical repair must be attempted. Vaginal cleansing and treatment of any urinary infection are essential preliminaries *Possibility of spontaneous closure*

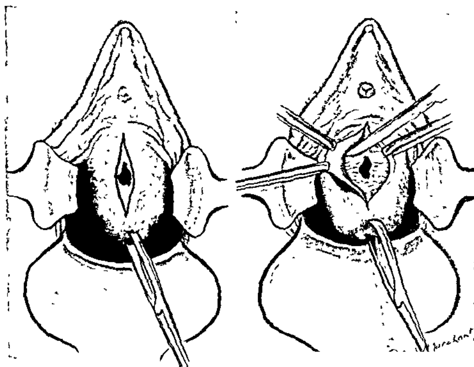


FIG 201 —Vesico-vaginal fistula Longitudinal incision, encircling the fistula I

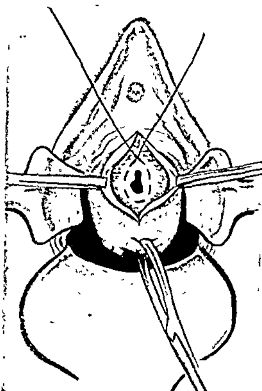


FIG 203.—*Purse-string suture in bladder wall.*

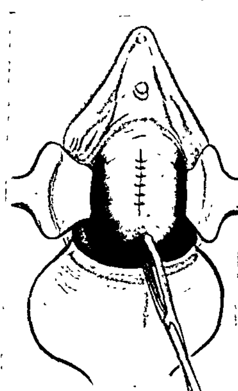


FIG 204—Vaginal wall sutured

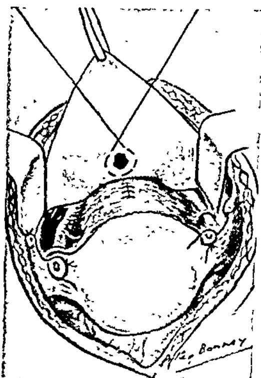


FIG 205—Transperitoneal approach; vagina sutured and purse-string suture in bladder fistula.

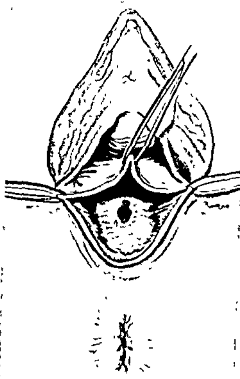


FIG. 206—Posterior vaginal wall separated from rectal fistula.

Most vesico-vaginal fistulae can be repaired by the vaginal approach, with the patient in the lithotomy position. An Auvard speculum is inserted and the cervix is pulled down with volsellum forceps; lateral retractors may also be needed (Fig. 201). If the vaginal introitus is small, improved access may be gained by a Schuchardt incision in the perineum. A longitudinal incision is made in the anterior vaginal wall, encircling the fistula. The edges of the vaginal wall are grasped with tissue forceps and the bladder is separated from it, as in anterior colporrhaphy (Fig. 202). This mobilizes the bladder and allows suture of the fistula without tension; it may also be necessary to free the bladder from the cervix. The fistula margin should be excised, and it is noteworthy that when the opening in the bladder mucosa is exposed it is always larger than the vaginal opening. A purse-string suture of 20-day chromicized catgut is passed through the muscle coat of the bladder round the fistula, so that when the suture is tied the hole is closed and the edge is inverted into the bladder (Fig. 203). When the opening is large it must be closed by interrupted sutures. The pubo-cervical fascia should now be brought across with catgut sutures and finally the vaginal wall is sutured with a continuous catgut suture (Fig. 204) Difficulty may be experienced in closing the vaginal incision in cases of large vesico-vaginal fistulae, and some surgeons use the silver-wire suture technique for the vagina, as it is more likely to be followed by union when there is some tension. The alternative procedures are to relieve tension on the central incision by lateral incisions, which are allowed to heal by granulation, or to use pedicle grafts.

Vaginal approach

Incision

Excision

Suture

A self-retaining catheter is inserted and the bladder is kept empty by continuous suction for 5–7 days, thereafter the catheter should be closed by a spigot, and the bladder is emptied every 4 hours; finally the catheter is removed on the tenth day, but daily catheterization for residual urine is advisable. Urinary infection must be combated with alkalis and sulphonamides. Occasionally haemorrhage occurs into the bladder shortly after operation and causes severe pain, it should be treated by irrigation with hot boric solution containing 1 in 1,000 adrenaline.

After-care

Vesico-vaginal fistulae and vesico-cervical fistulae which are close to either ureteric orifice, and all ureteric fistulae, must be approached through the abdomen. The best access to a high vesico-vaginal fistula is by a trans-peritoneal retro-vesical approach, with the patient in full Trendelenburg position. Through a midline incision the uterus is pulled upwards and the peritoneum of the utero-vesical pouch is opened from one round ligament to the other. The anterior peritoneal edge is pulled up and the bladder is separated from the cervix and the vagina, exposing the fistula, which is then closed with a purse-string suture (Fig 205) It may be necessary to identify the ureters before closing the fistula, and this will be rendered easier by previous ureteric catheterization. Bladder drainage with a urethral catheter is instituted as before described.

Abdominal approach

Incision

Suture

Bladder drainage

Intravesical repair by the extraperitoneal suprapubic route does not give good access to these fistulae, and requires a head-lamp and special forceps and needles.

Intravesical repair

When a ureteric fistula is present alone or with a vesical fistula, the peritoneal cavity must be opened. In all cases of ureteric fistula anastamosis of the ureter should first be considered. The anastamosis should be

Ureteric fistulae

performed over a ureteric catheter which acts as a splint, and a temporary nephrostomy can be performed at the same time. Alternatively the divided ureter may be transplanted into the bladder, if this can be done without tension; if not, it must be transplanted into the colon.

Transplantation of ureters

Colpocleisis

Very large fistulae, which cannot be closed owing to deficiency of tissue, and fistulae due to malignant disease or radium necrosis, are best treated by bilateral ureteric transplantation into the colon, provided there is normal sphincteric control. Occasionally it is preferable to perform colpocleisis, transforming the upper part of the vagina into the bladder by plastic closure of the lower part.

(2) Faecal fistulae

Obstetric fistula

A fistula between the anal canal and the lower part of the posterior vaginal wall is not uncommonly seen, as a result of imperfect healing of a third-degree tear of the perineum during labour, and usually it is of small size. Very rarely a fistula follows injury to the bowel during perineorrhaphy.

Gynaecological causes

Larger recto-vaginal fistulae may occasionally be caused by ulceration of a neglected or ill-fitting pessary, by tuberculous or syphilitic ulceration, or perhaps more commonly by malignant disease of the cervix, vagina or rectum; in addition a fistula may be caused or hastened by the use of radium, particularly if it has been inadequately screened.

The involuntary passage of faeces and flatus through the vagina is very distressing for the patient, and invariably sets up vaginitis; on the other hand, small obstetric fistulae may not cause much discomfort.

Treatment

Surgical repair should be preceded by thorough cleansing of the vagina, bowel wash-outs, and intestinal chemotherapy with succinylsulphathiazole or phthalylsulphathiazole.

Indications for colostomy

In malignant cases colostomy must be considered as a palliative measure, or as a preliminary to radical surgery. For large fistulae in the posterior vaginal fornix a temporary colostomy is also advisable.

Ano-vaginal fistulae

For an obstetric fistula in the lower third of the vagina, the perineal tissue is divided in the midline up to the fistula. Scar tissue is excised and the vaginal wall is separated from the rectum above the level of the fistula. After careful suture of the anal mucosa, the retracted ends of the anal sphincter are sought and sutured, and the perineal body is reconstructed by 2 or 3 deep sutures through the levator ani muscles. These can be tied after suturing the vaginal wall, and the perineal wound is then closed with interrupted silkworm gut sutures.

Recto-vaginal fistulae

Recto-vaginal fistulae in the middle or upper third of the vagina are best approached per vaginam (Fig. 206), as in the operation of posterior colpo-perineorrhaphy (*see* Pelvic Organs—Displacement, Vol. 6, p. 478). The vaginal wall must be separated from the rectum all round the fistula and scar tissue must be excised. The opening in the rectum is then closed and covered with fascia propria, before repairing the vaginal wall and perineum.

The bowels should not be opened for 5 or 6 days after this operation, during which time the patient is kept on a fluid diet. Liquid paraffin should

then be given by mouth, and a small enema of warm olive oil will ensure an easy painless action. *Post-operative regulation of the bowels*

7. NEW GROWTHS OF THE VAGINA

(1) Vaginal cysts

Vaginal cysts are not very common and rarely attain a large size. They are most often found in the anterior wall, and are thought to arise from the remnants of Gartner's ducts. Such cysts are lined by cubical epithelium and contain watery fluid; they are usually thin walled, and the vaginal wall covering the cyst is smooth and thin. Very occasionally a chain of 2 or 3 small cysts is found. Inclusion cysts lined by squamous epithelium occasionally occur after lacerations produced by childbirth, or after plastic operations for prolapse; they are usually small and occur more often in the posterior wall than in the anterior wall. *Gartner's ducts* *Inclusion cysts*

A vaginal cyst may be felt by the patient, particularly if it is low down in the anterior wall, otherwise they are symptomless. Excision of the cyst is usually a straightforward procedure. *Excision*

(2) Vaginal fibromyoma

This is of rare occurrence and resembles a uterine fibromyoma; it may become pedunculated. Enucleation of the tumour is readily performed, and is necessary if the tumour is causing symptoms.

(3) Vaginal papilloma

Benign papillomas have been recorded in infants, and occasionally occur in adults in association with vulval warts. They may be treated with podophyllin resin or by diathermy excision.

(4) Endometrioma

Endometrioma of the vagina is not uncommon in the posterior fornix, to which it spreads from the pouch of Douglas and recto-vaginal septum. It usually presents as a papillary mass, which causes irregular bleeding, perhaps on intercourse; occasionally small blood cysts are formed. Endometriosis will also be present in other pelvic organs as a rule, and this will determine the extent and nature of the treatment.

(5) Carcinoma of the vagina

(*a*) *Primary carcinoma*

Primary carcinoma of the vagina is a rare condition, and its frequency in relation to carcinoma of the cervix is about 2 per cent. The common age incidence is from 40 to 60 years and it bears no special relationship to parity. There appears to be an increased incidence in women with prolapse, especially if they have worn pessaries. *Incidence*

Nearly all primary growths of the vagina are squamous-cell carcinoma, but primary adenocarcinoma has been recorded and presumably arises from the remnants of Gartner's ducts Carcinoma may arise anywhere in the vagina, but it is said to be more common in the posterior wall. Owing to the relative thinness of the vaginal wall, invasion of the deeper structures, rectum, *Cell type* *Direct spread*

bladder or urethra, occurs comparatively early, and may cause fistula formation. The growth may involve a considerable area of vaginal wall by lymphatic permeation. The lymphatic drainage of the upper third of the vagina is the same as that of the cervix, mainly to the iliac glands; from the lower third, lymphatics drain to the inguinal glands and to the medial group of external iliac glands; lymphatics from the middle third drain by either or both of these routes.

Lymph glands

Bleeding and discharge are the commonest symptoms, and diagnosis must be made by biopsy. This will determine the cell type and probable response to irradiation. In view of the greater frequency of secondary carcinoma search must always be made for a primary growth in the uterus or bowel.

Biopsy

Treatment of primary carcinoma of the vagina has not been attended by a high rate of cure; this is partly because of technical difficulties in irradiation, and partly because radical surgery presents formidable problems.

Radium treatment

Radium is the method of choice and first line of attack, but correct application to the growth is of great importance. The methods of irradiating carcinoma of the cervix are inadequate for vaginal cancer, and interstitial radium is not recommended. It is possible to make a mould of dental stent, into which the radium is inserted so that it will lie over the growth and irradiate the whole vagina; special applicators have also been designed, such as the one described by Way (1948) to enable effective irradiation to be given to the growth, and at the same time to protect parts which are not involved.

Treatment of glands

As an ancillary to radium Way (1948) recommends block dissection of the inguinal glands for growths in the lower part of the vagina, and iliac adenectomy for growths in the upper part, and he believes these operations are preferable to deep x-ray therapy. Colostomy is necessary when a rectal fistula is present or if stenosis of the rectum follows irradiation, and bilateral transplantation of the ureters is indicated if the bladder is involved.

Colostomy

Transplantation of ureters

Radical surgery is only needed for tumours which do not show a response to radium, and may have to be preceded by either colostomy or transplantation of ureters according to the site of the growth. An extended Wertheim's hysterectomy should be performed for growths of the upper third, but the vaginal approach is preferable for growths of the middle or lower third of the vagina.

(*b*) *Secondary carcinoma*

Incidence

Secondary carcinoma of the vagina is much more frequent than is primary carcinoma, chiefly because of the frequency of direct extension from the cervix. Metastatic nodules are not uncommon from corporeal carcinoma, and occasionally from carcinoma of the rectum, bladder or ovaries.

Chorion-epithelioma

The vagina is one of the more common sites of metastasis in chorion-epithelioma, which may present as a dark bluish haemorrhagic nodule; such a secondary deposit may be the first thing to draw attention to the presence of a uterine chorion-epithelioma.

Treatment

The treatment of secondary carcinoma of the vagina is palliative, except when a cervical growth is limited to the vaginal fornices.

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[References to other titles are given under Uterus—Cervix; and Vagina, in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 12, p. 416]

UVEAL TRACT

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1. ANATOMY AND PHYSIOLOGY

342.] The uveal tract consists of the iris, the ciliary body and the choroid. It is richly vascular and so is the main source of intra-ocular nutrition, for only the inner layers of the retina are supplied by the end arterioles from the four main branches of the central retinal artery.

Chromatophores

The uveal tract has an elastic and connective tissue framework in which the chromatophores, star-like cells with long branching processes and with

pigment granules in their cytoplasm, are disposed throughout the tract. Its blood supply comes from the short posterior ciliary arteries, the two long ciliary arteries and the anterior ciliary arteries. *Blood supply*

The veins from the iris and ciliary body drain into the anterior ciliary veins and those from the choroid drain into the four vortex veins which pass obliquely through the sclera behind the equator in the line of the lateral and medial borders of the superior and inferior rectus muscles respectively.

The choroid nourishes the outer layers of the retina and so is essential for the preservation of sight.

The uveal tract plays many important parts in the function of the eye, mainly nutritive, including the production of aqueous and the maintenance of intra-ocular pressure, in the control of light entering the eye through the action of the sphincter and dilator muscles of the iris, in accommodation of the lens for focusing near objects, and to some extent in the drainage of aqueous by opening the canal of Schlemm when the scleral spur is drawn backwards by contraction of the longitudinal fibres of the ciliary muscle. The pigment in the choroid and iris is protective, against light, and diminution or absence of this pigment, as in albinos, causes photophobia. An increased volume of blood in the choroid during some vascular crisis may precipitate an attack of acute congestive glaucoma. It is evident that the ravages of inflammation of the uveal tract may damage vision in several ways, by impairing the function of the ciliary body so that the intra-ocular pressure is raised to a dangerous height and later lowered so that hypotony and shrinkage of the eye occur. Inflammatory exudates may occlude the pupil, adhesions may bind it down so that the circulation of aqueous into the anterior chamber is impeded, and adhesions of the iris root to the posterior surface of the cornea in the filtration angle may cause complicated glaucoma. *Part in function of eye* *Drainage of aqueous* *Hypotony*

Entanglement of uveal tract in a penetrating wound is a source of anxiety in surgery as a factor in causing sympathetic ophthalmitis.

Extra-ocular extension of malignant neoplasms of the uveal tract occurs along the lines of least resistance, such as emissary veins and the entries of arteries and nerves.

2. CONGENITAL DEFECTS

Congenital malformations of the uveal tract are coloboma of the iris and aniridia, persistent pupillary membrane, corectopia and polyopia, coloboma and congenital absence of the choroid. These conditions are not amenable to surgery and will not be described in detail.

3. INJURIES

(1) Contusions

Injuries due to a blow with a blunt object may cause tears and displacement of the uveal tract. Radial splits in the pupil margin are seen in pugilists. Some of these extend through the sphincter iridis. Damage to ciliary nerves passing to the sphincter iridis causes traumatic mydriasis.

The iris may be torn at its root where it is thinnest. The iridodialysis is associated with a D-shaped pupil and in severe cases the crumpled, folded and displaced iris may block the normal site of the pupil, or indeed the iris *Iridodialysis*

may be torn away from the ciliary body almost completely and lie rolled up in the bottom of the anterior chamber. Cyclodialysis is separation of part of the ciliary body from its attachment to the scleral spur. It rarely occurs after a contusion.

Cyclodialysis

The choroid is sometimes torn in a curve at the posterior pole of the eye between the optic disc and the macula. The concavity of the curve faces to the nasal side. Several splits may be present. More rarely the tear is on the nasal side of the optic disc. Immediately after the injury the edges of the rupture are fringed with blood, later white exudate outlines it and eventually pigment is deposited around it and the sclera shows through the split (Plate V). Sometimes the outer layers of the retina over the choroidal rupture are damaged, certainly the blood supply of these layers becomes impaired and a scotoma exists.

Scotoma

Detachment of the choroid and large choroidal haemorrhages sometimes follow severe contusions of the eye.

Treatment

For ruptures of the choroid, which are generally associated with commotio retinae, rest in bed for a week or longer is necessary. Atropine is inadvisable for radial splits of the iris as these may be increased in size by mydriasis and tear into the sphincter iridis. In severe cases of iridodialysis an operation may be done to draw the iris clear of the pupil and suture its root into the filtration angle, aiming to create an anterior peripheral synechia which will hold.

(2) Penetrations

Penetrating wounds of the cornea and corneo-scleral junctions are frequently associated with prolapse of the uveal tract which becomes contaminated by contact with the conjunctival sac and the air. Prolapse of the choroid is less marked in scleral wounds and may not be present at all. If the wound has traversed a large vessel such as a long ciliary artery or a big tributary of a vortex vein severe intro-ocular haemorrhage occurs.

Prolapse

Treatment

Treatment is directed to careful wound toilet. A conjunctival flap is fashioned to cover the wound and when sutures are necessary to close it these are placed ready to tie immediately the abscission of the exposed and damaged uveal tract is completed. Care is taken to ensure that no uveal tissue, or tag of lens capsule, when the lens is also damaged, remains entangled in the wound with a risk of sympathetic ophthalmitis.

Sympathetic ophthalmitis

In cases in which the penetrating wound passes through choroid and retina it is well to circumvallate the wound by a few applications of surface diathermy, 80–90 milliamperes for 7 seconds, so as to produce a ring of choroid-retinal adhesions and prevent retinal detachment.

4. DETACHMENT OF THE CHOROID

Detachment of the choroid is sometimes a post-operative complication following a trephine operation and after a cataract extraction. A dark, smooth-surfaced hemispherical swelling appears generally in front of the



Rupture of choroid. *(By courtesy of Oxford University Press)*

PLATE V

equator and occupies about a quadrant of the globe. Sometimes two hemispherical swellings are present, separated by a cleft. The fluid in the suprachoroidal lymph space is serous. Detachment of the choroid may also follow a contusion of the eye and complicate scleritis. *Clinical features*

Treatment

Spontaneous recovery through absorption of the fluid generally occurs. If the detachment persists for more than 2 months and shows no sign of absorption it is justifiable to reflect a conjunctival flap, puncture the sclera with a diathermy needle 1 millimetre long, using a current of 40–50 milliamperes for 2 seconds, and apply suction over the site of the penetration.

5. INFLAMMATION

The origin of inflammation of the uveal tract may be either exogenous or endogenous.

(1) Exogenous

Infection through a penetrating wound of the cornea and sclera may lead to the rapid onset of endophthalmitis and panophthalmitis within 48 hours.

Treatment.—Such a calamity is obviated by careful wound toilet. Any uveal tissue which has been exposed in the conjunctival sac is cleansed with saline irrigation and drops of penicillin, 2,500 units per millilitre, the tissue is seized with fine forceps, withdrawn 1–2 millimetres from the wound, and the line of abscission is through uveal tissue which has not been exposed in the conjunctival sac. The uveal tissue is then carefully freed from the edges of the wound so that none is left entangled when the wound is closed and covered by a conjunctival flap. Subconjunctival injections of pure Crystalline Penicillin G (Glaxo), 100,000 units in 0·5 millilitre of Novocain with adrenaline, are made at 6-hour intervals by day and night for 3–5 days, or larger doses, 500,000–1,000,000 units in 0·5 millilitre, are given at 12-hour intervals. The concentration of penicillin inside the eye and in the vitreous is therapeutically adequate in dealing with most penicillin-sensitive organisms. *Penicillin*

Bacillus coli infections have subsided by using streptomycin by the intramuscular and subconjunctival routes and with aureomycin drops. It is dangerous to inject penicillin and streptomycin into the vitreous. *Streptomycin* *Aureomycin*

Sympathetic ophthalmitis

This is a severe plastic iridocyclitis which affects the injured eye and its fellow. The cause remains unknown.

The disease is characterized by a flush of conjunctival and episcleral vessels around the limbus, corneal oedema, the presence of large yellowish white deposits on the posterior surface of the cornea (keratic precipitates—k.p.), plastic exudate in the aqueous, on the iris, in the pupil and surrounding the lens. *Clinical features*

The incidence of sympathetic ophthalmitis is highest within 3 months of the injury and the longer time that elapses after this without any suspicious signs appearing the less likely is this tragedy to occur. *Incidence*

Treatment.—Prevention consists in careful toilet of a penetrating wound and the closest observation for a year or more after the injury.

One of the most difficult decisions to make in eye surgery is whether to keep or to excise an eye which has sustained an injury liable to cause sympathetic ophthalmitis, and is to be regarded as a problem which requires the expert advice of an ophthalmologist.

(2) Endogenous

Most cases of uveitis are due to infection through the blood stream. In some instances the clinical features of the uveitis are characteristic and this is particularly so in the case of syphilis, tuberculosis, leprosy and gonorrhoea.

Associated diseases

In many cases the uveitis shows no specific features and in such cases an allergen, either bacterial or chemical, a virus, some associated disease of the reticulo-endothelial system such as *Boeck's sarcoidosis, uveo-parotitis* and endocrine and metabolic disturbances such as diabetes, gout and rheumatism are associated with the disease and blamed either as the cause or a complication.

It is evident from clinical and experimental work that certain strains of streptococci lodged in a primary focus of infection such as the roots of teeth have specific selectivity for the tissue of the uveal tract.

In many cases of uveitis, despite the most thorough clinical and pathological search for focal sepsis, no attributable cause is found and doubts come as to whether the disease arises *sui generis*.

Attacks of active inflammation may last 2 months and much longer. Recurrences are common and the effects of uveitis are devastating to sight.

(a) *Symptoms*

The symptoms of uveitis are photophobia, blurred vision, and inflammation of the iris and ciliary body, and there is lacrimation and neuralgic pain referred to the frontal and temporal regions which is often worse at night. The pain increases and may be constant both day and night if complicated (secondary) glaucoma occurs as a result of the high albuminous content and large molecules in the aqueous being unable to gain entrance to the canal of Schlemm. Blurring of vision is also increased in complicated glaucoma due to corneal oedema. In cyclitis and choroiditis cellular infiltration of the vitreous and the presence of exudate in it will cause the patient to complain of opaque floating spots.

Pain

Blurring of vision

(b) *Signs*

Iridocyclitis

In iridocyclitis there is a flush of conjunctival and episcleral vessels around the limbus. A mauvish tinge accompanies the congestion of the deeper vessels. Lacrimation is present and the cornea may be slightly hazy from oedema of the substantia propria, a feature which is more evident in complicated glaucoma.

Cyclitis

In cyclitis the posterior surface of the cornea shows the presence of keratic precipitates which are yellowish white dots composed of phagocytes adherent to the sticky inflamed endothelium and disposed roughly in a triangle with its base below and apex about the centre of the cornea (Plate VI, Fig. 1). The larger dots are at the base of the triangle and the smaller near the apex. In

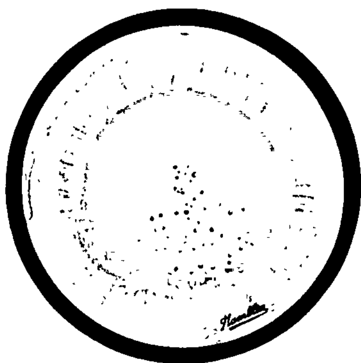


FIG 1 —Keratic precipitates in iridocyclitis (*By courtesy of Messrs. J & A. Churchill Ltd.*)

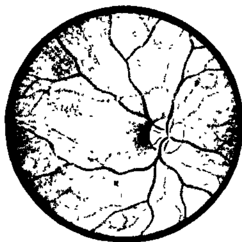


FIG. 2 —Miliary tubercles in the choroid associated with tuberculous choroiditis. (*By courtesy of Messrs Henry Kimpton.*)

PLATE VI



FIG. 1.—Gumma of the iris. (*By courtesy of Messrs. J & A. Churchill Ltd*)



FIG. 2.—Syphilitic (disseminated) choroiditis. (*By courtesy of Oxford University Press.*)

PLATE VII

tuberculous iridocyclitis keratic precipitates are large, greyish white, greasy-looking and confluent and have been aptly described as "mutton-fat" keratic precipitates. The aqueous contains a "flare". *Tuberculous iridocyclitis*

In gonococcal iritis there is a characteristic greyish green exudate in the anterior chamber and pupil. *Gonococcal iritis*

The depth of the anterior chamber is increased in cases in which the highly albuminous aqueous accumulates and its drainage into the canal of Schlemm is impeded.

In leprosy little white nodules of chronic granulation tissue are seen in the iris stroma. *Leprosy*

Exudates and cellular infiltration of the vitreous are seen with the ophthalmoscope and the binocular microscope and slit-lamp. In the anterior part of the vitreous these changes are associated with cyclitis and anterior choroiditis, and behind the equator are associated with an area of choroiditis in which the inflammation has extended into the retina.

Acute choroiditis is seen with the ophthalmoscope as a raised white area with a fluffy ill-defined edge. The overlying retina has lost its transparency and is involved in the inflammation, and in front of this the vitreous is hazy owing to infiltration with inflammatory cells. When the acute inflammation subsides there is left a white, flat, scarred area flecked and fringed with dark brown pigment in which the choroid and retina are adherent. *Acute choroiditis*

Tuberculous choroiditis may be manifested by a single conglomerate mass, a raised mass adjacent to the optic disc (choroido-retinitis juxta-papillaris), and miliary tubercles which are seen as round, raised, white areas, about 1–2 millimetres in diameter, between the optic disc and the equator and up to 20 or so in number (Plate VI, Fig. 2). These changes may be seen about four days before fatal termination from tuberculous meningitis, death being the patient's fate before the days of streptomycin injections. *Tuberculous choroiditis*

A gumma of the choroid appears as a large fluffy yellowish hemispherical mass.

The signs of an inflamed iris are a "muddy" colour due to exudate and oedema in the swollen stroma, occlusion of the anterior crypts and exudate on its anterior surface. The mobility of the swollen turgid iris is impaired so the pupil reactions are sluggish and the size of the pupil is small. The radial vessels of the iris are congested and obvious. The outline of the pupil is irregular when posterior synechiae adhesions have occurred between the pigmented posterior surface of the iris and the anterior lens capsule. In severe cases, particularly in diabetes mellitus, haemorrhages may occur in the iris stroma and into the anterior chamber (hyphaema). In neglected cases inflammatory exudate may fill the small irregular pupil (occlusio pupillae) and a complete ring of adhesions surround the pupil margin (seclusion pupillae). In the latter case the circulation of aqueous fluid into the anterior chamber is impeded, and it accumulates in the posterior chamber behind the iris which it presses forward (iris bombé). The inflamed iris root adheres to the cornea (anterior peripheral synechia) and, blocking the filtration angle, induces complicated glaucoma. In tuberculous iritis miliary tubercles may appear in the stroma or a single conglomerate nodule is evident. A third clinical type is a diffuse iritis which clinically has no specific features and has been attributed to the effect of tuberculo-proteins from destroyed tubercle bacilli in some healed focus acting as an allergen. *Inflamed iris* *Hyphaema* *Tuberculous iritis*

In syphilis a gummatous buff-coloured nodule may appear on or near the pupil margin and broad posterior synechiae are a feature (Plate VII, Fig. 1).

Syphilitic choroiditis

Syphilitic (disseminated) choroiditis is characteristic (Plate VII, Fig. 2).

The complications of uveitis and the special investigations required in these conditions demand the experience and skill of an ophthalmologist, and as they do not come within the province of the general surgeon they will not be described here.

(c) *Treatment*

(i) *General.*—The cause of uveitis must be dealt with promptly when such is found. The rapid improvement which follows the removal of an infected tooth and the opening of a sinus is sometimes remarkable. It is necessary to eliminate buried septic stumps with adjacent osteomyelitis of the jaw by alveolectomy.

Alveolectomy

In luetic uveitis rapid improvement follows one or two injections of neoarsphenamine. Penicillin and the sulphonamides are effective in treating organisms sensitive to their action but they have no effect on uveitis not due to these micro-organisms. When a tuberculous cause is suspected tuberculin may be used with great caution, starting with an initial dose of a millionth of a milligram.

The intestinal flora may be changed by the administration of lactose and lactic acid bacillus cultures and by the administration of sulphaguanidine.

Prostatitis and seminal vesiculitis are treated by medical diathermy as well as penicillin and the sulphonamides when these are appropriate.

Diabetes mellitus, gout, rheumatism, arthritis and dysentery should receive appropriate medical treatment.

Protein shock, or artificially induced pyrexia, is of value in some cases. Intravenous injections of 25 million units of TAB vaccine followed in 48 hours by 50 million and 48 hours later by another 50 million are helpful and I think the results are better than the intramuscular injection of 10 millilitres of boiled milk. The use of hypertherm cabinets does not seem to be so satisfactory as intravenous TAB injections.

Atropine ointment

(ii) *Local.*—Mydriasis and cycloplegia must be effected as soon as the diagnosis is made. Atropine ointment, 1 or 2 per cent, is applied to the conjunctival sac twice or thrice daily and is absorbed through the cornea. The ointment is more effective than drops, some of which are lost by overflow on to the cheek or drainage down the naso-lacrimal duct. The purpose of atropine is to place the inflamed iris and ciliary body at rest by paralysing the intrinsic muscles of the eye, by dilating the pupil to break down posterior synechiae and to prevent seclusio and occlusio pupillae. If atropine is ineffective in breaking down posterior synechiae which have become firmly established for several days, then a subconjunctival injection of 3–5 minims of

Mydricain

Mydricain, a solution containing atropine, cocaine and adrenaline, at the [illegible] particularly [illegible] vessels in cases of complicated glaucoma.

Atropine allergy

In cases of allergic reaction to atropine, which is characterized by follicular [illegible] alternative mydriatics [illegible] tic mydriatic, [illegible] must be substituted. Very rarely the use of atropine [illegible] particularly in

children, will be followed by signs of systemic poisoning; fever, delirium, flushing of the face and dryness of the throat.

Heat is applied to the inflamed eye in one of three ways: by medical diathermy, by an electrically heated eye-pad, or by steam from a wooden spoon covered with a large pad of lint and dipped in a deep bowl or jug of boiling water. Sessions of about 10–15 minutes are given thrice daily and follow the instillation of atropine ointment. *Heat application*

(iii) *Surgical intervention.*—As a general principle it is most undesirable to touch any actively inflamed intra-ocular structure. Surgical intervention is, however, indicated when complicated glaucoma occurs, and when the anterior chamber becomes full of pus (hypopyon) or blood (hyphaema). *Indications*

When iris bombé is present due to a complete ring of posterior synechiae, transfixing iridotomy is done by passing a narrow knife through the iris bombé in two places, thus re-establishing a communication between the posterior and the anterior chambers. In some severe cases when the posterior surface of the iris is extensively plastered down to the anterior lens capsule an iridectomy is necessary. *Iridotomy* *Iridectomy*

In cases in which the anterior chamber is full of highly albuminous fluid containing inflammatory cells and there is complicated glaucoma, paracentesis of the anterior chamber is done in the lower temporal quadrant at the limbus, and if necessary this incision is re-opened daily to evacuate the aqueous. *Paracentesis with anterior chamber wash-out is also done for* severe hypopyon and hyphaema. *Paracentesis*

In severe cases of complicated glaucoma which will not respond to paracentesis and re-opening of the anterior chamber and in which the intra-ocular pressure remains at a high level, dangerous for vision, a trephine operation with iridectomy is done.

6. NEOPLASMS

(1) Benign

A haemangioma of the choroid may be associated with congenital naevus flammeus affecting the area of skin supplied by the first and second divisions of the fifth cranial nerve. The increased volume of the intra-ocular contents due to the haemangioma and possibly some associated intra-ocular congenital vascular abnormality causes hydrophthalmia (infantile glaucoma). *Haemangioma*

Von Recklinghausen's disease (neurofibroma) affecting the ciliary nerves as these traverse the choroid increases the volume of the intra-ocular contents by the large size and tortuosity of these nerves, and so hydrophthalmia is a complication of this disease. *Neurofibroma*

Benign melanoma of the choroid has the ophthalmoscopic appearance of a smudge of blue ointment. After many years of innocency it may become malignant in some cases. *Melanoma*

(2) Malignant melanoma

(*a*) *Pathology*

Malignant melanoma of the choroid is a rare disease. Statistics from large clinics show the incidence to be about 0·07 per cent of patients attending on account of eye disorders. There are a few cases recorded in the literature *Heredity*

which suggest that heredity has played a part. There are also a few cases reported in which malignant melanoma has followed unilateral melanosis oculi, and also in which, after some years, malignant changes have become superimposed on a benign melanoma, more commonly in the iris than in the choroid.

(b) Sex incidence

Males and females are about equally affected in malignant melanoma of the choroid and ciliary body and there is a slight female preponderance in malignant melanoma of the iris.

(c) Age incidence

The disease occurs most commonly during the sixth decade of life. It has been noted in a male child, aged 1½ years, and in a male 87 years of age.

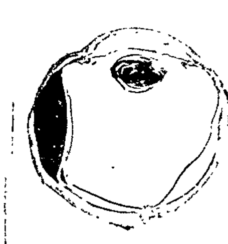


FIG. 207.—Malignant melanoma of the choroid Lenticular shape.



FIG 208 —Malignant melanoma of the choroid. Bruch's membrane has ruptured Collar-stud shape of growth. Retinal detachment.

(d) Affected eye

There is no preponderance of the neoplasm occurring in one eye more than the other and very rarely are both eyes affected (Fuchs (1882), 5 cases; Martin-Jones (1946) and Stallard (1948) 1 case each). Two separate and distinct neoplasms have been described in the ciliary body of one eye.

(e) Site of the neoplasm

The neoplasm is in the choroid in 85 per cent and in most cases it is at, or behind, the equator; in 9 per cent the ciliary body is affected and in 6 per cent the iris.

(f) Stages of growth

In the choroid the neoplasm begins as a lenticular shaped swelling (Fig. 207) and the retina lies closely applied to it.

upture of ruch's embrane

The neoplasm may be slowly growing and remain in this lens-shaped stage for a year or more. Eventually Bruch's membrane ruptures and through the gap there occurs rapid proliferation of malignant cells which, growing along

the lines of least resistance, fashion a mushroom or collar-stud like growth (Fig. 208) with degenerate atrophic retina closely applied to the summit; around this prominence the retina is detached.

As the neoplasm and the retinal detachment increase the iris-lens system is pushed forwards, the filtration angle becomes narrower and occluded, and the presence of plasmoid fluid in the anterior chamber and the increased volume of the intra-ocular contents cause complicated (secondary) glaucoma. *Complicated glaucoma*

Later still extra-ocular extension of the neoplasm occurs along lines of least resistance, for instance the sheaths, lumina and perivascular lymphatic spaces of blood-vessels leaving and entering the eye, and the posterior ciliary nerves. The vortex veins are involved in a neoplasm near their site of exit and the same applies to the anterior ciliary vessels. The neoplasm may split the scleral lamellae and extend in the interlamellar spaces. Extra-ocular extension of the neoplasm into the orbital tissues leads to its rapid growth. At first the intra-ocular pressure falls, the eye may be temporarily less painful and shrink. Later the shrunken eye, full of growth, becomes displaced forwards as the orbital extension increases. *Extra-ocular extension*

Metastases may occur at any time after a large vessel is invaded by the neoplasm or, indeed, cells may be forced into the circulation in manipulating the eye during excision.

It is evident that metastases in some cases may lie relatively dormant for 17–21 years. These occur commonly in the shafts of long bones, giving rise to "spontaneous" fractures, in the skull, sternum and vertebrae, in the liver, lungs, spleen and lymph glands. Melanogen is not at present detected in the urine by the Thormählen test until it is there in amounts large enough to be associated with metastatic deposits in the liver. *Melanogen*

Malignant melanoma of the iris may appear in several forms. The nodular form is generally situated in the stroma between the pupil margin and the root of the iris. The neoplasm shows small loops of dilated thin-walled vessels on its surface and in the adjacent iris stroma about its base. Karyokinetic figures are not seen in sections of the neoplasm and it is often slowly growing. In a few instances pigmentation is absent or almost so, the neoplasm having a white appearance. The flat, plaque-like type with a rough, fluffy brown surface occurs near to or in the iris root, and extending posteriorly into the filtration angle it distorts the adjacent iris and may produce eversion of the pars iridica retinae on to the anterior surface of the iris stroma (ectropion uveae) in the affected quadrant. The diffuse, "ring sarcoma", is characterized by an infiltration of iris stroma in the form of the diffuse flat growth which it is sometimes difficult to detect until the iris is picked up in forceps. The anterior chamber becomes shallower and complicated glaucoma occurs *Nodular form* *Flat type* *Ectropion uveae* *Diffuse form*

The degree and distribution of pigment are very variable. Some growths are heavily pigmented throughout, others are mottled, and some are white.

Between the bundles of malignant cells there are collagen, elastin and reticulin (argyrophil) fibres. Reticulin is picked out by its affinity for silver stains, collagen and elastin are not impregnated by silver salts.

Some malignant melanomas have no reticulin, in some it is irregularly distributed and in others there is a good network either throughout the neoplasm or surrounding it like a capsule. There has been some evidence

Prognosis

to suggest that the presence or absence of reticulin influences the prognosis; when it is absent the prognosis is bad and when a rich network or surrounding capsule is present life is prolonged.

(*g*) *Symptoms and signs*

The symptoms depend upon the site of the neoplasm. A small growth at or near the macula will cause visual loss and distortion earlier than a large mass in front of the equator. The presence of a shadow is noted in the visual field and this shadow enlarges rapidly as the retinal detachment increases. Movements of the inter-retinal fluid will cause flashes of light due to stimulation of rods and cones.

Congestive glaucoma

The onset of an acute attack of congestive glaucoma with pain, vomiting, and prostration may first draw the patient's attention to any defect. The anterior ciliary and episcleral vessels over the site of a malignant neoplasm are characteristically dilated and dark in colour. The ophthalmoscopic appearances of a malignant melanoma of the choroid are shown in Plate VIII. A dark brownish grey solid mass is seen beneath the retina, which is stretched and smooth over the summit of the neoplasm. Over the base of the neoplasm the retina is detached when the growth has burst through Bruch's membrane. There is no hole to be seen in the retinal detachment and the inter-retinal fluid between the layer of rods and cones and the retinal pigment epithelium is more turbid than in simple idiopathic retinal detachment.

Dilated thin-walled vessels may be seen on the summit of the neoplasm and sometimes there is a haemorrhage from one of these vessels.

A malignant melanoma of the ciliary body will show on oblique illumination. If it has infiltrated the iris root there will be a black crescent or ellipse in the filtration angle, and the shape of the pupil will be altered to a D instead of being circular. Pressure of the growth on the lens causes a localized subcapsular cataract.

(*h*) *Diagnosis*

On the discovery of any evidence of the presence of a melanotic growth the advice of an ophthalmologist must be sought, as the diagnosis and differential diagnosis of these neoplasms can be dealt with only by an expert.

(*i*) *Treatment*

Excision of the eye as soon as possible after the diagnosis is made is the correct treatment. The optic nerve and the structures at the posterior pole are cut through 10 millimetres or so behind the posterior pole of the eye as extra-ocular extension may have occurred along the sheath and lumen of a vortex vein or along the posterior ciliary vessels and nerves.

Exenteration of the orbit

When extra-ocular extension has occurred the prognosis as regards prolongation of life is not appreciably improved by the mutilating operation of exenteration of the orbit. The results are no worse if the orbit is submitted to deep radiotherapy.

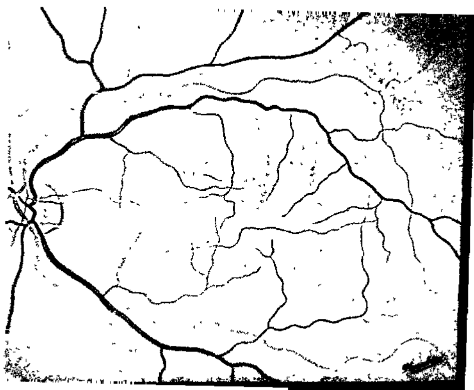
Iridectomy

It is in my opinion quite unjustifiable to excise an eye with useful vision for a malignant melanoma of the iris when the growth is limited to the iris and has not infiltrated the cornea or the filtration angle. A wide iridectomy of the sector of the iris containing the growth is performed. A patient on whom this was done is still alive and well with no evidence of metastases 16 years after operation.



Fundus appearance of malignant melanoma of choroid. Retina is smoothly applied over the summit of the neoplasm and lines of torsion are present in the retina near the base of the neoplasm. (*By courtesy of Oxford University Press.*)

PLATE VIII



Fundus painting of metastatic carcinoma of the choroid at the left macula.

PLATE IX

Treatment by radon seeds sutured to the sclera or by a plaque, either 5 or 10 millimetres in diameter, curved to fit the sclera and containing inside its 0·5-millimetre thick platinum envelope a disc of filter paper impregnated with radium salt, is indicated when a malignant melanoma occurs in an only eye or when it is bilateral. The prognosis is quite good if the neoplasm is in the lenticular stage and has not ruptured Bruch's membrane to make a collar-stud shaped growth. One patient, a man, treated thus is still alive 10 years after operation in which four 2-millicurie seeds were sewn over the site of the neoplasm. *Radon seeds* *Radium salt*

(j) *Prognosis*

The prognosis is best in the spindle-cell variety of malignant melanoma, particularly when little pigment is present, when there is a rich reticulin network throughout the neoplasm or surrounding it like a capsule and the neoplasm shows no evidence of infiltration of the sclera or of extra-ocular extension.

The prognosis is worst in the mixed-cell type of growth, for few survive longer than two years after excision of the eye. It is also bad when the neoplasm has extended through the sclera at the time of excision of the eye and when reticulin is absent.

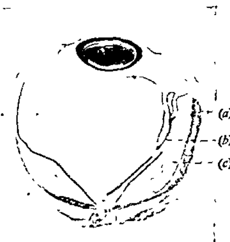


FIG. 209.—Metastatic carcinoma of the choroid Lower power view (*a*) Islands of carcinoma cells infiltrating the choroidal stroma; (*b*) detached retina, (*c*) subretinal fluid

(3) Carcinoma

(*a*) *Primary*

Primary carcinoma of the ciliary body epithelium may occur in an area of epithelial hyperplasia. It is very rare. The neoplasm infiltrates the root of the iris, may contain areas of cystic degeneration with cell debris as the contents, and pressure of the neoplasm on the lens capsule produces a localized subcapsular cataract. *Cystic degeneration*

Treatment.—If the neoplasm occurs in an only eye, or the other eye is seriously injured and of little use, irradiation by a radon seed or seeds or a radium plaque sewn to the sclera beneath the conjunctiva over the site of the neoplasm is justifiable. Otherwise excision of the affected eye is the operation of choice. *Irradiation*

(*b*) *Metastatic*

Metastatic carcinoma more commonly occurs in the choroid than in the iris and ciliary body. An embolus of malignant cells is carried into the eye through a posterior ciliary artery. Columns of carcinoma cells infiltrate the choroid and extend forwards from the posterior part of the eye (Fig. 209). The blood-vessels are replaced or choked by the carcinoma cells, the chromatophores are rolled up into small brown spherules, there is slight lymphocytic infiltration at the advancing edges of the tumour, and the arrangement of the tumour cells simulates that of the primary neoplasm, that is, the arrangement

is acinous with colloid material when the primary growth is in the breast, and papilliferous arrangement when it is in a bronchus or in the lungs (Fig. 210).

As the neoplasm increases the retina becomes detached, the detachment being shallow and having a greyish yellow reflex (Plate IX).



FIG. 210.—Metastatic carcinoma of the choroid. High-power view of advancing edge (*a*) Islands of carcinoma cells infiltrating the lymphatic spaces of the choroidal stroma; (*b*) retinal pigment epithelium; (*c*) sclera.

Site In about 60 per cent of cases the primary growth is in the breast and in 10 per cent it is in a bronchus or lung. About 1 per cent originate in the stomach, intestinal tract, and genito-urinary system.

In the case of a primary growth in the bronchus or lung the ocular metastasis is often the first indication of anything amiss, the small primary growth having defied detection by clinical examination.

Metastatic carcinoma in the uveal tract precedes death by about 7-11 months. Sometimes both eyes become affected. A metastatic nodule in the iris sometimes causes severe inflammation of the anterior segment of the eye and may at first be misdiagnosed as a chronic granuloma.

Treatment.—Carcinoma is radio-sensitive and in the early stages of the metastasis in the eye and in view of the possible occurrence of this catastrophe in the other eye it is, I think, justifiable to suture radon seeds or a radium plaque to the sclera over the site of the neoplasm and so lessen some of the patient's misery in the remaining months of life. The alternatives are to excise the eye or to leave matters alone until pain makes excision necessary.

Irradiation

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[illegible] *Ophthal.*, Monograph Suppl. XI.
[illegible] *thal.*, 32, 618.

[References to other titles are given under Uveal Tract in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 12, p. 495.]

VASCULAR SURGERY

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1. COARCTATION OF THE AORTA

Site

343.] Coarctation of the aorta may occur at any level from the carotid arteries distally to the bifurcation of the aorta, but the most common site is within a short distance beyond the origin of the left subclavian artery.

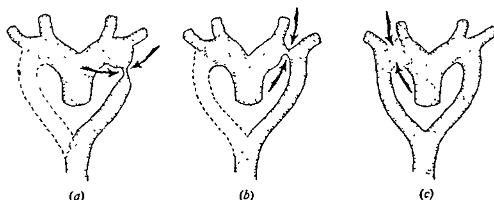


FIG. 211 —Areas of abnormal obliteration or stenosis in development of aorta and great blood-vessels, resulting in coarctation or causing the right subclavian artery to arise to the left of the left subclavian artery. (*a*) Coarctation of aorta, type A ; (*b*) coarctation, type B (less usual than type A), (*c*) abnormal origin of right subclavian artery beyond left subclavian artery.

The condition may be associated with the disappearance of the right aortic arch seen in early embryological life (Fig. 211).

Incidence

The incidence of coarctation is exceedingly low, forming 1 per cent of congenital heart lesions.

(1) Diagnosis

Probably most cases of coarctation are of minor degree and if the collateral circulation is well developed there are no disabling effects. When there is sufficient obstruction to produce symptoms, these are the result of the

increase of pressure above the level of obstruction and of too low a pressure distal to the site.

In the head and upper extremities the patient has a sense of increased pressure, perhaps headache, going on in later stages to the effects of hypertension with degenerative vascular disease, and ending with cerebral haemorrhage, rupture of the aorta or other vessels, and coronary artery disease. There may be a sensation of throbbing, distress and fullness over the precordium and in the lower neck region, and of pounding of the heart. In the lower extremities there may be weakness and inadequacy on exertion, probably as a result of too little circulation. *Symptoms*

(2) Examination

Examination may show a fairly normally developed individual. The most striking feature is marked pulsation in the suprasternal notch and supraclavicular fossae, as well as marked pulsation of the precordium. Palpation of the neck will demonstrate that this pulsation comes from enlarged subclavian vessels (Fig. 212) and the aortic arch which has risen to this level. The patient may be nervous and flushed, in a condition resembling hyper- *Pulsation*

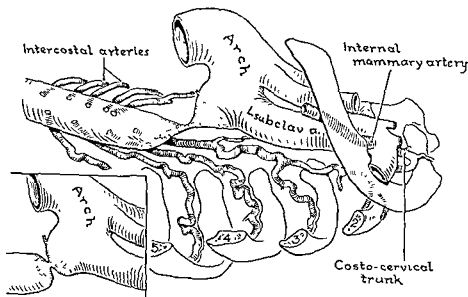


FIG 212.—Diagram of coarctation of aorta just beyond origin of left subclavian artery, showing stenosed area, enlarged subclavian artery and numerous collateral vessels bridging the stenosis *Inset*. a shorter area of stenosis, more approaching a diaphragm in the aorta.

thyroidism. The eye grounds may show haemorrhages similar to those seen in hypertension. The radial and ulnar vessels throb forcibly. In the scapular regions, along the vertebral borders and the inferior angles, tortuous vessels may be seen pulsating, and on palpation these can be identified as pulsating collateral arteries. Blood-pressure readings provide important information, the level in the upper extremities being above normal, while in the lower extremities it may be absent or well below that of the upper. Skiagrams of the chest show notching of the lower borders of ribs from three to eight, frequently most marked on the left side. *Skiagrams*

notches in one or two ribs, or the lower borders of all the ribs in these areas may show excavation. The shadow of the aorta beyond the arch, if seen, may be smaller than normal.

Catheterization

Substantial proof of the coarctation may be obtained by retrograde catheterization through radial or brachial arteries, care being taken to ensure that the catheter goes into the descending and not the ascending aorta. When it has reached an obstruction at the site of the coarctation, as visualized on the fluoroscope, about 30 millilitres of 70 per cent Diodrast are quickly injected and immediately two or more x-ray films are exposed in rapid succession. This may demonstrate the lesion satisfactorily (Gross and Hufnagel, 1945; Crafoord and Nylin, 1945; Blalock and Taussig, 1945)

(3) Indications for and against operation

To consider what should be done once the diagnosis has been made, it is well to realize the prognosis in these patients if not treated surgically. As is well illustrated by Abbott (1915), some of these patients live through a natural span of life with little disability, and seem to be energetic and intellectual people. Relatively few patients have disturbing symptoms in early childhood. However, during the teen age and early twenties, symptoms tend to make their appearance, and from then on, in the majority, there is a progressive hypertension disabling the patient, until within the third or fourth decade most of the patients have succumbed from vascular accidents.

Vascular injury from hypertension

It is the author's experience (Murray, 1949), which agrees with that of Gross and Hufnagel (1945), Crafoord and Nylin (1945) and others, that most patients beyond 20 years of age or thereabouts have had so much vascular injury from the hypertension that they do not benefit much, and are not greatly improved symptomatically, by operation.

If the symptoms and physical findings are severe enough to consider operation, the fact that the patient is facing disability and probably an early demise must be balanced against the dangers of the undertaking, and in a patient over 20 years of age, with the greater danger of the operation and the smaller chance of improvement, operation is not advised.

Ideal age

It is the author's experience that the younger the patient when the operation is undertaken, the easier is the procedure and the better are the results to be expected, and the ideal age from both these points of view is about 8–12 years.

(4) Operation

Preparatory to the operation a large quantity of blood should be available, and intravenous fluid running into two or more veins is a good precaution.

(a) *Exposure*

Approach

A dorsilateral incision or an exposure through the second or third interspace, antero-laterally, may be used. In the posterior approach (Fig. 213) a vertical incision is made so that the third, fourth and fifth ribs can be divided close to the costo-transverse articulations. The sixth rib is removed subperiosteally to the mid-axillary line and, on going through this bed, the pleura can be opened with little danger from bleeding from the enormously enlarged

Opening the pleura

intercostal vessels. A great number of superficial dilated vessels must be dealt with *en route*. The necks of the fifth, fourth and third ribs are divided together with the intercostal bundles and the bleeding is controlled. Getting through the chest wall and into the thorax is a major procedure because of the size and number of greatly dilated, tortuous, thin-walled arteries.

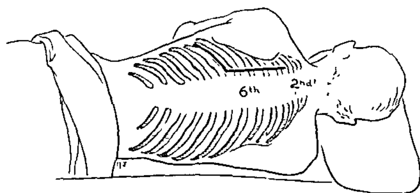


FIG. 213.—Posterior incision for repair of coarctation or tetralogy

When the pleura is opened, the lung and its hilum fall downward and forward, exposing the arch of the aorta, the heart, with the descending aorta and the constricted area of the coarctation. Usually the constriction is immediately beyond the left subclavian artery, and the latter is enormously enlarged to almost the diameter of the aorta distal to the site of the obstruction. *Usual site of constriction*

If the obstruction involves only a short distance of the length of the aorta with a deep depression in the form of a diaphragm, the prospects for excision and end-to-end repair are excellent. In most patients, however, the stenosis is an elongated, spindle-shaped, hour-glass effect, necessitating excision of 1–1½ inches of the aorta before an adequate lumen at each end is obtained. Under these conditions, the problem arises whether an end-to-end suture can be carried out or whether, after excision of the affected area, the proximal end should be oversewn and closed and the left subclavian artery divided distally and brought down to be anastomosed to the distal portion of the aorta. Recently, Gross has bridged such a gap with a graft of preserved aorta, Blalock has left the coarctation undisturbed and has circumvented the area by doing an end-to-side anastomosis between the divided subclavian artery and the aorta distal to the stenosis (Blalock and Taussig, 1945). The pleura over the aorta is incised for a distance of about 4 inches. With light dissection the vagus and its recurrent branch are identified.

The ligamentum arteriosum is identified and in most of my patients there has been a patent ductus of small proportions requiring division and ligation. *Patent ductus* The thoracic duct and oesophagus lie immediately deep to the aorta and to the transverse portion of the arch The hilum of the lung falls forward with the lung, which is one of the advantages of this posterior approach. On further inspection the greatly dilated collateral vessels coming off the aorta immediately distal to the stenosis can be seen. These are coursing to anastomose with those coming from the branches from the arch going to the scapular,

intercostal and internal mammary arteries. These enlarged intercostal arteries require very careful handling and constitute one of the chief difficulties and dangers of the operation. The aorta is fairly firmly tied down by these vessels. With the slightest carelessness, they may be either torn across or avulsed from the aorta, causing serious haemorrhage which is not easily controlled.

Risk of tearing intercostal arteries

It is good practice to mobilize the site of the stenosis, which is fairly easily done, to pass a surgical tape around it, when gentle traction will lift the aorta from its bed and expose these enlarged collateral intercostal vessels. By careful dissection a length of at least ½ inch of each one of these must be exposed then tied and divided between ligatures. Those on the proximal (left side) are controlled, following which those from the right side of the aorta can be identified and dealt with similarly. At least two and sometimes three pairs of these intercostal vessels must be tied off to allow sufficient mobilization of the aorta, first to bring it into a position where it can be sutured and secondly to allow it to be approximated to the divided upper end.

Control of intercostal arteries

(*b*) *Excision*

After sufficiently clearing the arch from the ligamentum or ductus arteriosum, and removing a good deal of fibrous tissue which is present around this area, the aorta proximal and distal is controlled by soft pressure clamps. My suggestion is not to use rubber-covered clamps because they tend to slip off more easily. Ingenious clamps designed by Potts are excellent and will not slip (Potts, Smith and Gibson, 1946). The stenosed segment is then excised, further sections being taken proximally and distally, if necessary, until practically a full lumen of the aorta is reached. The stenosed segment should be inspected. If the opening through the diaphragm in the specimen is exceedingly small, it gives one some impression of how important has been the collateral circulation, much of which has now been divided. Also, if there has been a high degree of obstruction with only a pin-hole through this diaphragm, the proximal segment of the aorta has been under very high pressure, which, if a successful repair is effected, will be suddenly released once the flow is re-established, and adequate precautions must be taken on this account to prevent disaster.

Potts's clamps

(*c*) *Repair*

(i) *Procedure when ends of aorta can be approximated.*—It must now be decided if the ends of the aorta can be approximated. If they do not come together without great tension, it is a mistake to attempt an end-to-end suture. If they do, a continuous everting mattress suture bringing intima to intima can be used (Fig. 214). This is started at a point most distal from the operator, passing from adventitia to intima, crossing to the other segment and passing from intima to adventitia, then back to intima again, and so on. When half a dozen or more sutures have been placed, pressure is applied to the clamps to approximate the ends and at the same time the sutures are gently drawn up. They should come together nicely without signs of tearing of the vessel wall. When further sutures have been applied, they are tied to a stay-suture to prevent slipping and loosening of the suture line. When the suture has been carried toward the operator for about a third of the

Mattress suture to ends of aorta

circumference, another suture should be commenced adjacent to the starting point and this should be carried around to keep both fields of suturing well within view and of easy access. As the suturing approaches the operator's side of the aorta it becomes easier and can be completed without difficulty. It is the author's custom at this stage to spray the interior of the aorta with heparin solution (10 milligrams per 10 millilitres of saline solution). *Heparin spray*

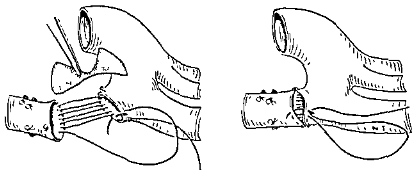


FIG 214.—Coarctation, showing part excised and method of suturing in end-to-end repair

If the ends are freely mobile, the application of three stay-sutures will approximate them, and one is used to rotate the aorta so that the suturing may all be done from the outside.

(ii) *Procedure when ends of aorta cannot be approximated.*—If the ends of the divided aorta cannot be approximated easily, further consideration is required to see whether sufficient length of the left subclavian artery can be obtained to reach the distal segment of the aorta. If such should be the case, the proximal end of the aorta is closed by sewing in such a way as to leave a small diverticulum, or no diverticulum. The subclavian artery is tied off

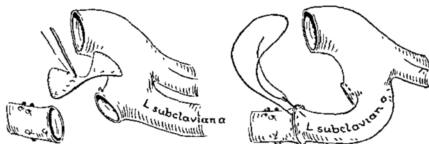


FIG 215.—Coarctation; resection of a long " hour-glass " stenosis and use of left subclavian artery to bridge the longer gap, after closure of proximal end of the aorta.

distally and the divided end is brought down to approach the distal segment of the aorta without tension (Fig. 215). It is surprising how the arch of the aorta and the subclavian artery tend to fall into a uniform curve, leaving the sewn-up proximal end of the aorta as a seam on the lesser curve. The suture of the subclavian artery to the distal segment of the aorta is carried out in a fashion similar to that already described. The author has left the aorta undivided in some cases, thereby avoiding much dissection and division of

collateral vessels, and then the divided subclavian artery has been anastomosed to the aorta beyond the constriction by the end-to-side method, as recommended by Blalock.

(d) Removal of clamp from aorta

A critical period of the operation now follows. The clamp on the distal segment of the aorta is removed with caution. If there should be some slight leak at the anastomosis, the everted flanges of tissue can be sewn together by continuous suture where it seems indicated. If there should be no leak, then the proximal clamp on the aorta is slowly and gently released, not allowing it to open fully. At this time the anaesthetist is cautioned to observe the blood-pressure most carefully. The operator himself observes the heart rate. If the clamp is suddenly released, the proximal aorta with its coronary and cerebral vessels, which has been accustomed to exceedingly high pressure, may suddenly be drained of most of its blood and left with a very low pressure so that within a very few seconds the patient may show signs of collapse from inadequate coronary or cerebral circulation. Releasing the clamp very slowly, however, will protect the patient against this, and by co-operation between the anaesthetist and the surgeon the time at which the clamp can be released fully can be decided from the ability of the patient to maintain blood-pressure spontaneously. Gross early became aware of these dangers, for he considers he lost his first patient because of the sudden fall of blood-pressure in the aorta and consequently in the coronary and cerebral vessels (Gross and Hufnagel, 1945). In several of my patients it has required from 30 to 40 minutes of gradual release, or release and reapplication of this clamp, before the patient could maintain his own blood-pressure in equilibrium at a reasonable level.

Effect on blood-pressure and heart rate

(e) Transfusion and closure of wound

If haemostasis has been well controlled throughout, these patients may not need transfusion. However, adequate amounts of blood should be available and administered *ad lib.*

Once the patient has reached this stage, it remains only to close the mediastinal pleura and the chest wall after final aspiration with a catheter and syringe.

Aspiration

(5) Post-operative care

The patient is returned to bed in an oxygen tent. The most interesting observation from the surgeon's point of view is the level of the blood-pressure in the arms compared with that in the legs after such a formidable procedure. Under ideal conditions, and especially in a younger patient, it has been observed that the pressure in the arms is much reduced from its original level and is equal to or only slightly higher than the pressure in the legs. Within the next few days there may be a rise of the pressure in the arms, which may or may not be followed by a similar rise of the pressure in the legs. Whether the original drop in pressure is the result of diminished blood volume or a vasomotor effect is not known; neither is the cause of the subsequent rise in pressure. Possibly the increased circulation through the abdominal aorta, with increased circulation to the adrenal glands, may be one factor. In any

Level of blood-pressure

case, within 7–10 days, there is a fairly well-stabilized pressure level which, under ideal conditions, remains equal in the legs and arms and is much below the hypertensive level present in the upper extremities before the operation.

The post-operative period demands careful observation of the chest, and if there should be signs of accumulation of blood, lymph or air, repeated aspiration is necessary. The patient remains in bed for about two weeks to allow sufficient time for solid healing of the suture line. Provided there has been a good result, the patient is ready for moderate activity in 4 weeks and for any sort of activity probably 2 months after the operation. *Aspiration*

(6) Prognosis

In younger patients, especially in children in the early teens, the blood-pressure may remain normal in arms and legs, the child returns to normal health in every respect and there is no remaining evidence of previous trouble. So far, the long-term end-results are not known, but the prospects are good; these children will have no permanent disability. On the other hand, in the older patients of about 20 years of age, the end-results are more in doubt and it is difficult to make predictions. Some patients are completely relieved of all symptoms, the pressure returns to a normal level in both arms and legs and the prospects are excellent. In others, however, in whom there is a persisting hypertension, more evident in the upper extremities, the patients are left with some residual symptoms. Beyond the age of 21–25 years, in the author's experience, which corresponds to that of Gross and Hufnagel (1945) and others, the results are so poor that it is doubtful whether it is justifiable to undertake an operation of this magnitude for the little improvement that can be expected. There may be too much vascular damage to allow a return of normal function, and it is doubtful whether the end-results of degenerative vascular disease will be much altered by the operation.

Patients in early teens

Older patients

Patients over 21–25 years of age

2. DOUBLE AORTA

Double aorta is probably the persistence of a vascular ring surrounding the trachea and oesophagus, seen in the amphibian type of bilateral aortic arch. Usually, in this condition, Nature has made an attempt at occlusion and separation at some point in the ring, but the occlusion is incomplete. This area provides an isthmus, usually situated in the anterior portion of the ring running in front of the trachea and oesophagus. It may, however, be in the posterior part and consequently be obscured behind the trachea and oesophagus where it must be *Definition*

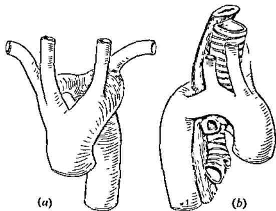


FIG 216.—Double aorta showing the vascular ring compressing the trachea and oesophagus and the arrangement of the great vessels (from a dissected specimen), (a) front view, (b) right lateral view.

searched for. Depending on just how far development has proceeded, the arrangement of the carotid and subclavian vessels will vary in relation to these two halves of the double aortic arch (Fig. 216). The symptoms are usually present at birth or very soon afterwards, and may be severe or mild. In general, the effects are compression of both trachea and oesophagus, giving difficulty with respiration and with swallowing. Barium in the oesophagus will be useful in identifying such an obstruction, as will skiagrams of the trachea, either with or without Lipiodol.

Symptoms

If there are any attacks of cyanosis in the newborn or if there are symptoms suggesting obstruction by the thymus, the possibility of double aorta must be considered.

Operation

Incision

Through a second or third left interspace, an incision is made from the margin of the sternum to the posterior axillary line. When the pleura is opened, there is a good exposure of the anterior portion of the arch, and a constricting vascular ring with an isthmus can be identified. It must now be determined whether division at this isthmus will allow adequate circulation to both right and left carotid arteries. If so, the isthmus is controlled with soft clamps distally and proximally, and after division the ends are either tied or oversewn.

Division at isthmus

If the isthmus is not evident on the anterior surface, then the pleura should be divided so that the aorta and descending arch can be mobilized. The upper one or two intercostal arteries may require to be divided to bring the aorta forward sufficiently to see whether there is a posterior segment of the arch running behind the trachea and oesophagus. If the isthmus should be found here, or if this segment is small, division of the isthmus will relieve symptoms.

Division at pleura

3. RIGHT SUBCLAVIAN ARTERY ARISING TO THE LEFT OF THE LEFT SUBCLAVIAN ARTERY

This condition is also a developmental error, in which the separation of the right half of the amphibian double aorta has occurred between the

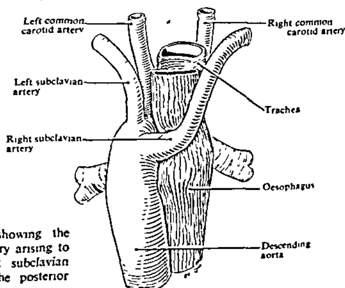


FIG. 217.—Diagram showing the right subclavian artery arising to the left of the left subclavian artery, seen from the posterior aspect.

right subclavian artery and right carotid artery rather than distal to the right subclavian artery. This leaves the attachment of this right subclavian vessel at the point at which the double arch of the aorta unites to form the single aorta below (Figs. 211 and 217).

The symptoms of the condition are roughly similar, but usually less severe than are those of double aorta. The condition produces compression of the oesophagus and perhaps of the trachea. Barium in the oesophagus and Lipiodol in the trachea again will give substantial proof of obstruction of these structures, giving support to the diagnosis (Fig. 218).

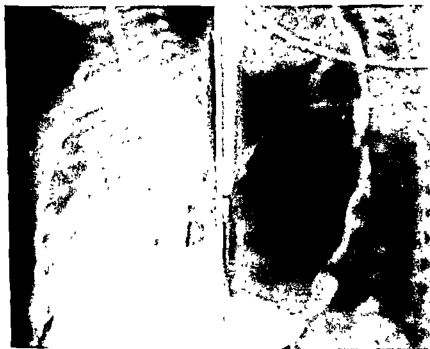


FIG. 218 —Right subclavian artery arising to the left of left artery: lateral skiagrams showing indentation of posterior aspect of oesophagus (in twins)

If the condition gives rise to any symptoms, the treatment is exposure through the second or third left intercostal space and exploration of the arch of the aorta. If the vessel is found passing transversely across the mediastinum from this area, it should be isolated and divided between ligatures, which will give complete relief. Circulation to the right hand is rarely impaired, but in any case is subsequently improved until it is normal again.

4. PULMONARY STENOSIS

The description by Fallot in 1888 of this condition followed a similar description by Peacock in 1887. The tetralogy is comprised of pulmonary stenosis, patent interventricular septum, dextra-position of the aorta, and hypertrophy of the right ventricle (Fig. 219).

Incidence

Of all heart diseases, the congenital variety comprises about 2 per cent, and of the congenital malformations, pulmonary stenosis comprises 5 per cent. Of congenital heart disease with cyanosis, however, 75 per cent have pulmonary stenosis.

(1) Pathological anatomy

Diversion of blood

As a result of the pulmonary stenosis, only a portion of the blood entering the right ventricle can be delivered through the pulmonary artery to the lungs, thus accounting for the cyanosis. The remainder of the blood escapes through the patent interventricular septum and is circulated unoxygenated from the left ventricle, together with that returning from the lungs, through the aorta to the systemic vascular tree. This diversion of a portion of the blood is assisted by dextra-position of the aorta, placing this structure astride the septum in such a position that it receives blood from both ventricles. The patent septum exposes the right ventricle to practically the same pressure as the left, accounting for the hypertrophy of the former. As a result of the incompletely oxygenated arterial blood, the tissues generally seek more oxygen, and the response to this is polycythaemia and an increased capacity of the whole vascular tree.

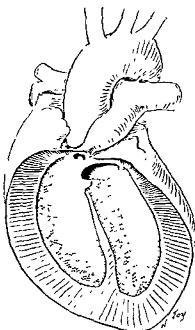


FIG 219—Diagram of heart in tetralogy of Fallot, showing pulmonary stenosis, patent interventricular septum, dextra-position of the origin of the aorta and right ventricular hypertrophy.

Specimens of congenital malformations show a great variety of deformities, but it is surprising how uniform are the findings in the heart of a child who has lived a few months or years, who was cyanosed throughout, and in whom a clinical diagnosis of tetralogy of Fallot was made. The heart is enlarged and much of the increase in size is the result of enlargement and hypertrophy of the right ventricle in its distal two-thirds. That portion forming the conus arteriosus (infundibulum) is usually conspicuously small, and the pulmonary artery arising from this is usually smaller than normal and in some cases is exceedingly small, or absent, while in others it is normal. When opened, the lack of development of the conus and of the pulmonary valves is evident. The latter may have only one or two poorly formed cusps. Rarely the conus and the pulmonary artery are normal, but at the site of the valves there is a deep hour-glass constriction and the valves may be partly fused to form a sort of diaphragm, resulting in functional stenosis (Brock, 1949).

Infundibulum

Stenosis

The opening in the interventricular septum is at the site of the pars membranacea septi and probably represents a defect in that portion of the septum formed from a downward growth from the partition separating the two aortae. The opening, from 1 to 2 centimetres in diameter, looks directly into the base of the enlarged funnel-shaped end of the aorta.

(2) Aetiology

Although the cause of this condition is not known, it is suggested by Blalock and Taussig (1945) that virus infections, especially German measles, occurring during pregnancy between the twentieth and forty-first day when cardiovascular structures are being developed to their adult form, may

inhibit development, resulting in this particular deformity. It has been suggested that congenital heart disease tends to be accompanied by other congenital malformations. However, in the author's experience in examination of 500 patients with congenital heart defects, there has been a very low incidence of other abnormalities.

Familial tendency

Regarding the familial tendency, in 500 cases examined there were only four in which there were more than one case of congenital heart disease diagnosed in the same family. In one family there were an aunt, an uncle, a cousin, two brothers and one sister. In another family, a brother and sister each had a patent ductus arteriosus, and one of these also had a patent interventricular septum. In the third family the brother of a child with a patent interventricular septum had died in infancy with an undiagnosed congenital heart lesion. The fourth family had identical twins, each with a right subclavian artery arising to the left of the left subclavian artery.

(3) Symptoms

The infant is blue from birth and, in the most extreme lesions, may be either born dead or survives only a short time. If conditions are slightly more favourable, the infant survives but is weakly and delicate throughout infancy and childhood. A great deal of extra nursing and care are required, because the child is subject to infections. The cyanosis tends to increase somewhat as the years go by and is accompanied by clubbing of the extremities, appearing after the first or second year and involving all fingers, toes and sometimes nose and ears. The skin is slate-blue in colour and dilated subcutaneous venules can be seen throughout. The mucous membranes of mouth, nose and conjunctivae show marked cyanosis and increased vascularity.

Progress

Dyspnoea

Dyspnoea at rest or on slight exertion is a striking feature. This is one of the most important tests on which to decide the severity of the lesion. In the worst cases the patient is bedridden, has little energy, and has so little reserve that the slightest exertion precipitates violent dyspnoea. In the next grade the patient is able to be up and walk a few steps but tires out so quickly that the squatting position is assumed—sitting on the heels, with the elbows on the knees and the chin in the cupped hands. This attitude brings into action the accessory muscles of respiration in an attempt to compensate for the dyspnoea. In the next grade there is moderate exercise tolerance, allowing walking short distances but at a slow pace only, and in spite of this, more or less dyspnoea and an increase of cyanosis occur. A few of these patients survive to adult life and may go on to later years. Most patients, however, are badly incapacitated in infancy and early childhood and the majority of them do not survive beyond adolescence.

Survival

(4) Examination

Clinical examination demonstrates moderate deformity of the precordium in some cases. On auscultation there is typically a systolic murmur in the second left interspace, which is transmitted along the great vessels for a short distance, and usually is heard in the interscapular region. The first heart sound is of fairly normal quality, but the second at the left interspace is soft and muffled and lacks the usual sharp snapping quality of the normal

Heart sounds

second sound. This is in marked contrast to the accentuated, loud, snapping second sound which is audible in pure patent interventricular septum or in Eisenmenger's complex. Frequently there is a palpable thrill in this area, but it is not strong.

Blood investigation

Blood investigation shows polycythaemia, with an increase of haemoglobin ranging up to 180 per cent; a red blood count ranging up to above 10,000,000, a white blood count moderately increased; a haematocrit reading from 55 to 70; and an increase in total blood volume. Arterial oxygen is low; in severe cases it may be below 40 per cent, cyanosis appearing only if the oxygen is below 70 per cent.

Radiography

The skiagrams show, in the typical case, enlargement of the right ventricle, some projection of the left ventricle to the left with double apices, suggesting the enlargement of the right ventricle projecting to this level (Fig. 220). There is a deep notch in the left border which in the normal heart is filled out by the presence of pulmonary conus and pulmonary vessels.

Fluoroscopy

Fluoroscopic examination adds more information. There is no pulsation, or a very quiet appearance in the hilar region on each side. On a transverse view there is adequate space between the vertebral column and the heart, and with barium in the oesophagus the latter is not compressed by the heart, indicating that the auricles are not enlarged. In the antero-posterior view indentation of the barium in the oesophagus demonstrates the position of the aorta. In most patients it lies on the left of the vertebral column, but in the author's group, 20 per cent of cases had the aorta descending on the right. The lung fields do not show congestion and the lung vessels are not prominent and show no visible pulsation. The window through the arch of the aorta which, if in the normal position, is seen in the left anterior oblique view, shows as a space indicating the diminutive size of the pulmonary vessels. The electrocardiogram shows right axis deviation.

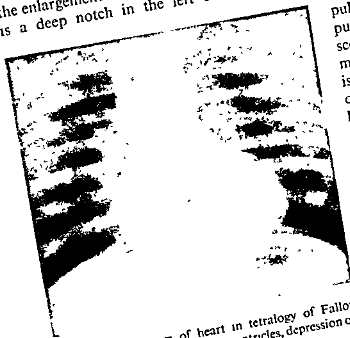


Fig. 220.—Skiagram of heart in tetralogy of Fallot, showing enlargement of both ventricles, depression on left border of heart at site of infundibulum.

Catheterization

In many patients, investigation to this point will give sufficient evidence to make the diagnosis of a tetralogy. If, however, there is doubt, or if confirmation is desired, catheterization (Cournand and his colleagues, 1945) of the heart may be carried out, providing further information. A No. 5 or No. 7 ureteral catheter is passed through a basilic, jugular or saphenous

vein, but preferably through the left median basilic vein. It follows the venous system through the superior vena cava, the right auricle, the right ventricle and with good luck through the pulmonary artery and its branches, into the pulmonary field. At each of these sites, a sample of blood and a blood-pressure reading is taken. From this evidence can be determined the presence and the degree of shunt in patent interauricular septum, patent interventricular septum, patent ductus arteriosus or pulmonary stenosis.

Rise in blood oxygen

If there is a marked rise in blood oxygen in the right auricle, compared with the superior vena cava, together with increased pressure, this is fairly certain evidence of patent interauricular septum. In such cases also the catheter may fortuitously be passed through the hiatus into the left auricle and further into a pulmonary vein. If the oxygen saturation of the blood in the superior vena cava and right auricle is similar, but if the right ventricular oxygen is elevated above this level, it would suggest a patent interventricular septum with escape of oxygenated blood from the left ventricle into the right ventricle. If the catheter is passed into the pulmonary artery, an oxygen saturation here equal to that of the right ventricle, especially in the presence of a high pressure in the pulmonary artery, will suggest an Eisenmenger's complex. On the other hand, if there is a higher oxygen content in the pulmonary artery than in the right ventricle, together with a high pressure, it will suggest the presence of a patent ductus arteriosus.

Using this information and blood volume and flow, the amount of blood shunted from side to side has been computed and used as a basis for deciding whether operation is necessary and more or less what benefits might be expected (Bing, 1946).

Angio-cardiography

Angiocardiography (Furman, 1948), in which 70 per cent Diodrast is injected quickly through a peripheral vein to fill the right auricle, may give important evidence. It may outline the auricle; it may suggest the presence of a patent interauricular septal defect; it may outline the right ventricle and the course of the blood through the pulmonary artery into the left auricle; or it may show an escape through the septum into the left ventricle. Thus variations of cardiac architecture may be photographed under good conditions.

(5) Differential diagnosis

(a) Tetralogy of Fallot

This is distinguished by cyanosis from birth onward; clubbing of the extremities coming on during the second or third year; a systolic murmur over the second left interspace; polycythaemia; right axis deviation on electrocardiography; an enlarged right ventricle and projecting left ventricle with a deep notch on the left border seen in skiagrams and on fluoroscopy; and no pulsation in the hilar fields.

(b) Patent interventricular septum

If, however, instead of the deep notch in the left border there is an enlargement at this point on radiography and fluoroscopy, with marked pulsation, with or without cyanosis, with less disability and less limitation of exercise tolerance and less dyspnoea, the probabilities are that the case is one of patent interventricular septum, or of a patent ductus arteriosus. The distinction between these two is not easy to make, except on catheterization. The

murmur of a patent ductus arteriosus is a continuous bruit in typical cases, but this is heard only in about 70 per cent of cases. If the bruit in the pulmonary area is systolic only and is followed by a very loud snapping second sound, this is in favour of patent interventricular septum. On fluoroscopy the bulge on the left border is lower in a case of patent ductus arteriosus. The bulge tends to pulsate violently with a flapping appearance similar to a loose sail flapping in a breeze, whereas the strong pulsation of the enlarged pulmonary vessels in patent interventricular septum is a reciprocal pulsation with the left ventricle, which, while it pulsates forcibly, has not this flapping character, and is slightly higher on the left border than is the bulge of a patent ductus arteriosus. The aortic window is completely filled in both these conditions, and in transverse skiagrams the greatly dilated pulmonary vessels present in the interventricular septum condition can occasionally be demonstrated, in contradistinction to the blurred field seen in the patent ductus arteriosus. There tend to be fewer blood changes. With a patent ductus there is neve cyanosis, except occasionally for short periods. In the severe interventricul septal defects there is marked polycythaemia, cyanosis and clubbing, b none when the opening is small. Catheterization of the heart provides m important evidence (*see* p. 503).

Fluoroscopy

(*c*) *Interauricular septal defect*

Interauricular septal defect, if large, produces great enlargement of the heart silhouette (Fig. 221) involving right and left ventricles and both auricles, but chiefly the right. There is a great prominence in the left border of the heart from the enlarged pulmonary artery and infundibulum. X-ray examination with barium in the oesophagus may show this structure displaced

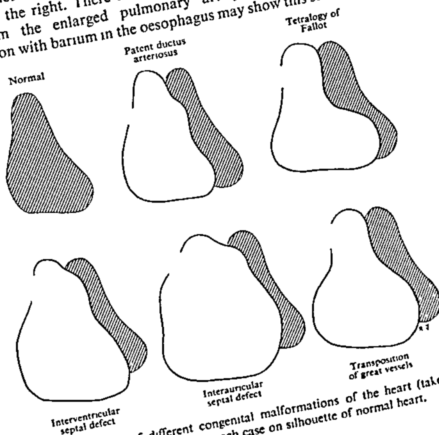


FIG 221 —Silhouettes of different congenital malformations of the heart (taken from skiagrams) superimposed in each case on silhouette of normal heart.

to the right and compressed antero-posteriorly by the greatly enlarged auricles. The striking feature is the great enlargement and congestion of the lung vessels throughout the whole pulmonary fields. Unless cardiac failure has supervened, the patient is not cyanosed and there is no clubbing. The bruit at the base of the heart is usually systolic, but it may have a diastolic element.

Congestion of lung vessels

(d) Transposition of the great vessels

Transposition of the great vessels is difficult to identify. The heart has a shape somewhat similar to that seen with a tetralogy except that the region of the great vessels is narrower. The heart has the appearance somewhat of an Erlenmeyer flask, whereas with a tetralogy it is more like a Florence flask. Probably the best evidence on which to distinguish this condition, taking all other points into consideration, is fluoroscopy. This shows the narrowness of the great vessel region, and on rotating the patient from side to side the antero-posterior relationship of the aorta and pulmonary artery may be identified. Catheterization of the heart is not of great value in determining this condition; some efforts have been made to correct it surgically, but so far they have met with little success.

Appearance of heart

(6) Indications for operation

In the case of the tetralogy of Fallot, the decision whether to operate or not must be made partly on laboratory evidence, but more particularly on clinical observation. The response to exercise is of paramount importance. If there is extreme limitation of exercise tolerance, with marked increase of dyspnoea and cyanosis, then the patient will have increasing disability and probably short survival. If, on the other hand, the patient has relatively good exercise tolerance, and can walk fairly well without increasing cyanosis or dyspnoea, it may not be necessary to undertake surgical treatment. Such a patient may adjust his routine of life to conform to the capacity of the cardiovascular system. On the other hand, if the patient has severe cyanosis which increases with exercise, increasing dyspnoea, well-marked clubbing and blood changes, and an enlarged heart, operation should be considered.

Exercise tolerance

Consideration must now be given to the age at which operation may be best undertaken. In the author's experience (Murray, 1947c), a child below 7 or 8 months of age is usually so under-developed that there is great difficulty in giving an anaesthetic safely. The operation can be accomplished quite satisfactorily at a still younger age, but the anaesthetic provides the strongest reason for deferring the operation to the age of 7 or 8 months. In the author's group of 200 cases operated upon for this condition, the youngest patient in whom operation was successful and done with reasonable ease was aged 8 months. From that age onwards, the decision depends largely on whether the child is under-developed or is fairly vigorous for the age. Probably the easiest and best time to undertake operation is between 5 and 6 years of age when the child can be given an anaesthetic with relative safety and the surgical procedure is simpler. At this age the field is not so far from the surface as in the larger individuals, the vessels are of sufficient size to be handled with ease, and the anastomosis is larger than that made in infancy, which may be an important factor if the fistula made in an infant does not grow in proportion to the growth of the child (Blalock and Taussig, 1945).

Age for operation

Anastomosis

It is wise to keep the child in isolation for a few days to be sure that there are no intercurrent infections or contagious diseases. Many of these children have enlarged tonsils and adenoids which have not been removed because of anaesthetic difficulties, and care must be taken to avoid infection from this source. It is a good plan with such children to have the heart condition remedied first, and when the child is in an improved state of health the tonsil and adenoid operation may be undertaken.

Tonsils and adenoids

(7) Operation for the tetralogy of Fallot

Credit for the inception of the idea of blood-vessel anastomosis to correct this condition must be given to Helen Taussig. Blalock, with his experimental background in vascular surgery, was the first to perform a successful anastomosis in a patient in an attempt to improve the circulation through the lungs (Blalock and Taussig, 1945). As a result of this, it is satisfactory to see most of these patients greatly improved, so that they change from a condition of semi-invalidism, requiring constant care, to one of activity, equal in many cases to that of normal children, and the repeated expressions of gratitude from parents suggest that this operation is well worth while in properly selected cases.

Prognosis

What the end-result over many years will be remains to be seen. In effect the operation is producing a patent ductus arteriosus, in the form of a fistula, between the aorta and pulmonary system. It is curious that when there is a patent ductus arteriosus steps are taken to close it; when there is pulmonary stenosis an attempt is made to produce a patent ductus arteriosus. However, the result seems to justify the end so far, and whether these patients will eventually develop bacterial infection as a result of this fistula, or whether they will develop cardiac decompensation can be determined only with further lapse of time. In the meantime, many children are returned to relatively good health and vigour and probably have survived for longer periods than if they had not been operated upon. The assessment of a group of these patients in, say, 20 years will be of considerable interest.

Principle of operation

The principle of the operation is to divert blood from the aorta, or from one of its large branches, to the pulmonary vascular tree, so that more blood will pass through the lungs and consequently a greater proportion of the blood will be oxygenated. This, when successful, overcomes most of the difficulties causing the patient's symptoms. In good cases the cyanosis disappears, as does the polycythaemia and clubbing, the exercise tolerance becomes normal, and the health, vigour and growth of the child are greatly improved.

(a) *Technique*

Anaesthetic

As the chest is to be opened, positive ventilation with an endotracheal catheter is a great advantage, but other forms of positive ventilation may be used. In the average patient, cyclopropane is probably best because of the high percentage of oxygen administered with it. In very small children, less than 1 year old, ether with a high percentage of oxygen is safer because of the inability of patients with such small tidal air to provide a satisfactory respiratory circuit through the machine.

Incision

Probably the best incision in small children is in the third left intercostal space, otherwise in the second space, beginning from the middle of the

sternum and extending laterally to just beyond the posterior axillary border (Fig. 222). The pectoralis major and minor are completely divided, as is the anterior inch of the latissimus dorsi. The nerve to the latissimus dorsi and the nerve of Bell are identified and retracted out of the field. The external intercostal and internal intercostal muscles are divided and *en route* large dilated vessels must be controlled. The pleura is opened and immediately the

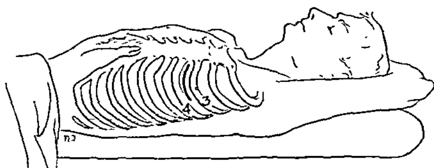


FIG 222.—Site of incision in front for repair of ductus arteriosus, or of tetralogy of Fallot.

internal mammary artery is dissected out, divided and tied. The costal cartilages above and below the incision are divided and a chest retractor applied. This can be opened sufficiently to expose the upper half of the pleura.

Pleura

The condition of the pleura is of considerable importance. In several of my patients the pleura has been completely obliterated either by adhesions or from a congenital condition in which the pleura is not properly formed. Crossing this field have been multiple anastomotic vessels going to the lung which caused considerable difficulty in securing haemostasis. The apex of the lung is swept downward and held lightly out of the field while inspection of the area is made.

Pulmonary artery

It is easy to determine whether the aorta is lying on the left or right side. Frequently over the hilum of the lung there is a heavy plexus of vessels which provide a collateral circulation to the lung. This must be handled with great care. My plan is to encircle these vessels and tie them off before dividing them. When this is adequately under control, dissection of the hilum of the lung will display the superior pulmonary vein running from below upward along the anterior surface. On carefully dissecting deep to this, the pulmonary artery running more transversely and whiter in colour can be identified. A thin sheaf of mediastinal fascia surrounds the pulmonary artery. If this is picked up gently and opened, it is very easy to dissect the pulmonary artery around its whole circumference. A heavy loop of silk is then gently drawn around this with a fully curved forceps. Continuing with sharp and blunt dissection, the pulmonary artery can be dissected out until its origin from the bifurcation can be identified, and distally till it divides into its branches. At least an inch of the pulmonary artery should be cleared so that it can be controlled adequately and to provide sufficient field in which to work.

Subclavian artery

Further inspection of the apical area of the pleura will identify the subclavian artery. When the pleura is divided over this artery, the phrenic and vagus nerves protected, and the artery encircled with a loop, traction and further dissection will define the origin of the subclavian artery from the

aorta. Care must be taken to avoid avulsion of its origin from the aorta, as this is the point at which it may easily give way. The vertebral artery is identified arising from the upper and posterior aspect of the subclavian artery. It is tied, as are the superior intercostal artery, the thyrocervical trunk, the internal mammary artery, and the main trunk of the subclavian artery just as it is disappearing over the inner border of the first rib. After applying a self-retaining arterial clip, the subclavian artery is divided across, together with its branches, and brought down into the field. It is compressed to empty it of blood and its lumen is filled with heparin, 10 milligrams in 10 millilitres of saline solution (Murray, 1940).

Length of artery

The length of the artery which will come down nicely to meet the pulmonary artery is estimated. If there is sufficient length of artery proximal to the origin of the vertebral artery, division at this point will give a larger cross-section for anastomosis, which is an advantage. On the other hand, if this is too short, pulling the subclavian artery down will angulate it too much at its origin, and will not allow a full flow of blood. It is necessary, therefore, to adjust the length so that it will make a nice curve coming off the aorta and still have the largest lumen possible.

Blalock prefers to use the subclavian artery coming off the innominate artery, and therefore he enters the chest on the side opposite to the aorta In this case the innominate, subclavian and carotid arteries are dissected out. When the subclavian artery is brought down it forms a better angle (nearer a right angle) than does this artery coming off the aorta. This dissection is somewhat more difficult.

Division of artery

Having decided the level, the subclavian artery is divided at one of its branches in such a way as to obtain a flared-out end, forming a sort of funnel. As the anastomosis is always slightly constricted, this flared end gives a moderate advantage. It has been the author's misfortune, in four operations, to find no pulmonary artery present, in which cases it has been impossible to do any operation to help the patients. If the subclavian artery is too short, especially in the older patients with a higher aorta, and with the pulmonary artery lying lower down, it may be impossible to do an anastomosis. This is one important reason for my preference for approaching on the side of the aorta, which gives one a choice of doing Potts's operation.

Potts's operation

In this operation the aorta is anastomosed directly to the pulmonary artery at the point at which the two cross.

If, however, the Blalock type of operation is to be proceeded with, the pulmonary artery is controlled by a clamp placed proximally just at its origin from the main truck, and the branches distally are encircled by snares of silk on which light weights, such as light forceps, are suspended for traction. These hold the lung down out of the field, stretch out the pulmonary artery and bring the whole area fairly well into view. The adventitia of the subclavian artery and that over a patch of the pulmonary artery on the antero-superior surface is excised, and the latter is opened at such a point that when the subclavian artery is brought down it will make a nice curve. If the point of opening is too medial it will bring the artery too snugly around the aorta, and if it is made too distal it will run into the branches. Therefore, the correct point between these two places must be selected. The pulmonary artery is opened by a transverse

Point of opening

incision forming a hiatus, which is slightly larger than the opening of the divided subclavian artery. The lumen of the pulmonary artery is emptied of blood and then filled with a heparin solution similar to that given earlier.

The author's preference is for small straight needles on which is threaded No. 5 waxed silk. The needle is brought through the subclavian artery from adventitia to intima, then through the pulmonary artery from intima to adventitia and back to intima again, then through the subclavian artery from intima to adventitia. This gives an everting mattress type of continuous suture When half a dozen or more such sutures have been applied loosely without attempts to approximate the vessels up to this point, light traction on the *Sutures*

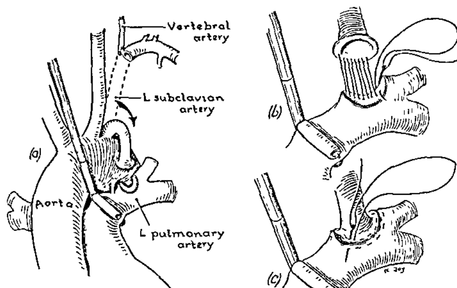


FIG. 223 —Left subclavian–pulmonary (Blalock) anastomosis showing (*a*) control of left branch of pulmonary artery ; (*b*) end-to-side approximation , (*c*) method of suturing.

suture with light approximation of the pulmonary and the subclavian arteries will bring the intimal surfaces together without difficulty (Fig. 223). A stay-suture now applied prevents slipping back of the tightened suture. The suture is continued along the posterior surface, approaching the operator. When a point has been reached along the anterior surface at which the posterior end of the suture begins to be obscured, another suture is started, tied to the original one, and then continued from the far side towards the operator along the anterior surface of the vessel. Before the final sutures are placed, the lumen of the vessels is filled with heparin solution and the suture completed and tied

The distal pulmonary snares are relaxed and the vessels allowed to fill. If there is no bleeding, the clamp is removed from the proximal end of the pulmonary artery, restoring the circulation through the lung. The anaesthetist is cautioned at these stages to watch for changes of the patient's pulse rate and blood-pressure. If the anastomosis is holding satisfactorily, the clamp is carefully removed from the subclavian artery. Immediately there is bounding pulsation through the subclavian artery transmitted to the pulmonary artery. This is accompanied by a strong thrill and sometimes a visible vibration. This thrill is felt sometimes through the substance of the lung on the parietal *Removal of clamp*

surface. Immediately following removal of the clamps, under good conditions, the anaesthetist is conscious of a change in colour of the patient, from a dusky cyanosis to a rosy pink. The mediastinal pleura is repaired in such a way that it elevates the hilum of the lung and relaxes the tension on the anastomosis. The intercostal nerve of the segments above and below the incision may be injected with 1 per cent Novocaine to relieve post-operative discomfort. Three wire sutures by which the ribs are brought together are placed encircling the ribs above and below. A catheter with an attached syringe is passed through the incision and down into the posterior sulcus

Repair of pleura

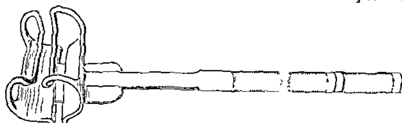


FIG 224.—Ingenious aortic clamp devised by Potts and Smith for use in the Potts operation.

behind the lung. The pectoralis major and minor muscles are repaired with a continuous suture. After a subcutaneous suture is applied, the chest is aspirated to remove any remaining blood, and as the skin suture approaches this area, the catheter is gradually withdrawn and any remaining air is removed. A light dressing is applied so that there is no constriction of the chest on this side. The patient's respiratory tract is cleared of mucus before he is returned to the ward. Usually there is no necessity for blood transfusion. If there has been a moderate loss of blood, such loss is an advantage, provided it has not produced clinical effects measurable by the anaesthetist. If too little blood has been lost, it may be an advantage to remove more blood to reduce the tendency to thrombosis

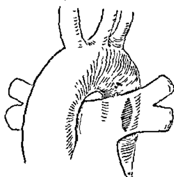


FIG 225.—Tetralogy of Fallot: Potts's method of direct anastomosis between left branch of pulmonary artery and descending aorta as they cross.

Intravenous heparin

As soon as the anastomosis has been completed and is dry, it is my custom to give sufficient heparin intravenously to raise the clotting time to about 10 minutes. The patient is then returned to the ward with the intravenous drip running, and into the tubing sufficient heparin (Murray, 1947a) is injected every 1½ hours to keep the clotting time at about 10 minutes. Through the tubing is administered Luminal Sodium in ¼-grain or ½-grain doses for sedation, also penicillin in adequate dosage. The patient is placed in an oxygen tent for 2 or 3 days or until such time as he can be removed from it without change of colour. Fluids may be given orally within a few hours of operation.

Oxygen

It is satisfactory to note at this stage that the patient's colour is changed and within a short time the health, vigour and appetite of the child are greatly improved. He is kept in bed for 10 days; the heparin is continued for 8 days. Following this, he is encouraged to exercise actively and to run up and down stairs daily before leaving hospital.

(b) Potts's operation

If the subclavian-pulmonary anastomosis is not feasible on the left side, the use of the right subclavian artery, as suggested by Blalock, may be more suitable. On other occasions, especially as the individual reaches adult age, the arch of the aorta seems to be higher up and the pulmonary artery slightly lower down. The vessels coming off the arch are therefore shorter and reach the pulmonary artery with more difficulty. Under these conditions, the author has found it an advantage to do Potts's operation, which is an anastomosis between the left branch of the pulmonary artery and the aorta where they cross (Potts, Smith and Gibson (1946)). The possibility of using this alternative operation has influenced the author in the decision to make the chest approach from the side on which the aorta is found to be, especially in older patients. *Alternative procedures*

The aorta is cleared of two or three intercostal arteries for a length of about two inches at a site just distal to the descending arch and at the level at which it is crossed by the pulmonary artery. Frequently this involves division of the bronchial arteries also. A clamp (Fig. 224) especially designed by Potts for this particular operation is applied. The pulmonary artery has been prepared as formerly and a continuous suture is applied anastomosing an opening on the posterior aspect of the pulmonary artery to the anterior surface of the aorta (Fig. 225). This operation can be done through either an antero-lateral approach or through a more lateral approach which gives slightly better access to the posterior aspect of the pulmonary artery. The opening in the aorta should be exactly 4 millimetres in length. If it is larger, there is too great an escape of blood from the aorta which may cause pulmonary congestion and embarrass the cardiac function. If it is less than 4 millimetres in length, there is not sufficient escape to produce the desired effect in overcoming cyanosis. *Incision of aorta*

The post-operative treatment in this operation is similar to that following subclavian–pulmonary anastomosis.

(c) Other operations

In a small percentage of patients presenting the symptoms and signs of a tetralogy, Brock (1949) has found the chief defect to be a diaphragm at the site of the pulmonary artery valves. In these patients he has performed a simple division of this diaphragm such as was done by French surgeons in 1889 by an approach through the right ventricle. In some others Brock has evidence, supported by comparative anatomy, that the site of stenosis is in the conus arteriosus (infundibulum) of the right ventricle. At operation in some of these patients, he has punched out a larger opening through this area in the ventricle with benefit to the patients. Other attempts to increase the pulmonary circulation, by making a by-pass around the site of stenosis, in the conus and valve regions, have not proved successful as yet.

5. PATENT INTERVENTRICULAR SEPTUM

Patent interventricular septum is considered the primary lesion in the heart when it is not accompanied by pulmonary stenosis, tricuspid atresia or transposition of the great vessels, and when it is in itself the only significant *Primary lesion*

lesion in the heart, with the exception perhaps of an accompanying patent interauricular septum. It may be complicated by dextra-position of the origin of the aorta.

(1) Aetiology

It is uncertain why an arrest of the development of the cardiac cushions should occur which, instead of completing the septum, leaves a hiatus at some point. Usually this occurs at the base of the septum (Fig. 226) where the latter should approach the annulus fibrosus, the usual site of the pars membranacea septi, but it may occur anywhere in the septum. A small opening 1, 2 or 3 millimetres in diameter, may cause a very loud murmur clinically, but may be of little significance as regards cardiac function. On the other hand, an exceedingly large opening, constituting practically a single ventricle or a trilocular heart, may not be compatible with life for more than a short span. Only those cases in which the opening is of such a size as to cause clinical symptoms and signs are considered for surgical treatment. This size varies from 1 to 2½ centimetres in diameter.

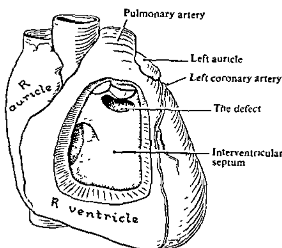


Fig. 226—Interventricular septal defect usually occurring at base of septum Method of closure is by fascial suture passed through the heart, parallel to the septum and lying over the defect on its left side.

(2) Symptoms

The symptoms may be more or less severe, depending on the size of the opening. On the average, the patient has less energy than usual and tends to fatigue more easily, although it is surprising how energetic some of these children may be. There is, with the larger openings, cyanosis, clubbing of the extremities and polycythaemia, but this is less noticeable than in the average case of tetralogy of Fallot.

(3) Diagnosis

Children with these lesions are not cyanosed at birth but as months and earlier years pass, cyanosis appears as does the clubbing and polycythaemia. Over the precordium there may be bulging. There is a harsh, rasping bruit which is heard about the mid-piece of the sternum and tends to be transmitted transversely or may be heard all over the heart area, but it is most concentrated at the mid-point of the sternum, and is accompanied by a thrill. The bruit is heard faintly in the interscapular region.

Bruit

Radiography

If the lesion is of clinical significance, there is usually enlargement of the

heart, involving both left and right ventricles. A characteristic appearance is a large bulge on the left border of the heart at about the site of the aorta and pulmonary vessels (Fig. 227). On the fluoroscopic screen, this bulge pulsates reciprocally with the left ventricle. It seems to expand slightly as if under great tension and does not have the loose flapping appearance which is so evident in patent ductus arteriosus. There is moderate pulsation in the hilar region on each side and in about 60 per cent of cases there is visible flashing out in the pulmonary fields, indicating the high pressure in the pulmonary vessels, with delivery of a large quantity of blood. Looking through the arch of the aorta in the left anterior oblique direction, there is no window visible, as this area is completely filled by an enlarged pulmonary vessel. In the lateral view, there is a clear space between the heart and vertebral column posteriorly, indicating no enlargement of auricles. Barium in the oesophagus will confirm the position of the aorta on the left side (this has been the case in all my patients) and the oesophagus is not displaced either from the midline or compressed antero-posteriorly. *Fluoroscopic appearance* *Barium swallow*



FIG. 227.—Skiagram showing a heart with an interventricular septal defect.

If the patient is cyanosed, this distinguishes the case easily from patent ductus arteriosus, in which latter case there is no cyanosis. If, on the other hand, the patient is not cyanosed, the question will arise whether there is a patent ductus (Fig. 228) or an Eisenmenger's complex. Under these conditions, catheterization of the heart probably has its greatest significance. The catheter, by determining the oxygen content of the right auricle, right ventricle and pulmonary artery, together with the blood-pressures in these chambers, will distinguish between Eisenmenger's complex and a patent ductus arteriosus. The chief effects are that the catheter will demonstrate a high right ventricular pressure with a rise in oxygen content at the base of the right ventricle when compared with the right auricle. This indicates a patent interventricular septum. Then, as the catheter is passed on into the pulmonary artery, which usually occurs with great ease, the oxygen content here is the same as in the right ventricle and there is high pulmonary artery pressure, while in the patent ductus arteriosus, with the high pressure, there is a rise in oxygen content because of the delivery of blood from the aorta into this system through the patent ductus arteriosus. *Value of catheterization*

Angiocardiography

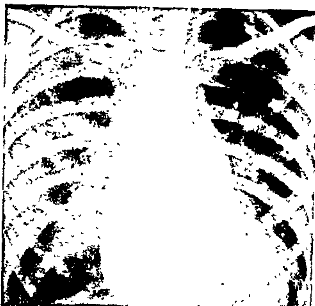


FIG 228 —Skiagram in case of patent ductus arteriosus, showing enlargement of heart, prominence on left border in region of infundibulum (conus), enlargement of pulmonary vessels in lung field, and congestion.

If good pictures are obtained by angiocardiography they also provide very substantial evidence of the presence of a patent interventricular septum by the early and rapid escape of the opaque substance (Furman, 1948).

(4) Indications for operation

This particular lesion is just coming into the field of surgery, and for that reason more caution is required in deciding for and against operation. At present, operation is undertaken only when a child is cyanosed, has marked limitation of exercise tolerance, and has considerable enlargement of the heart. If, on the other hand, there is a loud murmur, no cyanosis, no obvious disability, and only slight, if any, enlargement of the heart, such a lesion probably should not be operated on, for the present at least. As time goes on it may be decided that the number of patients with these relatively innocuous lesions who eventually develop bacterial endocarditis is sufficient to suggest that the lesions should all be closed. On the other hand, if the child is in exceedingly poor health and has an enormously enlarged heart, operation should not be undertaken because of the danger involved.

(5) Closure of interventricular septal defects

Anaesthetic

The patient is given endotracheal cyclopropane and oxygen or ether and oxygen anaesthesia, and during the operation, 0 1 per cent Novocain in saline solution is given intravenously. At least 200 millilitres of this solution are given before the heart is handled.

Incision

The incision is made through the first intercostal space on the left side extending out to within an inch of the lateral border of the pectoralis major (Fig. 229). It is carried downward slightly to the right of the middle of the sternum and out through the sixth intercostal space to the anterior axillary line. The internal mammary artery is tied in the upper space, and as the sternum and ribs are bent outward, the terminations of the internal mammary artery into the musculophrenic and superior epigastric arteries are also tied. The ribs are then bent until they are reflected back, forming a trap-door.

Incision of sternum

The incision down through the sternum with bone-cutting forceps is easily accomplished if the finger is run down extrapleurally, thus protecting the right pleura, to avoid a bilateral pneumothorax. The exposed pericardium is then opened by a vertical incision extending well up over the great vessels

and down to the attachment to the diaphragm. Two transverse incisions are made about an inch from either end of the first incision and the corners of the middle flap on each side are picked up with forceps, and with these the pericardium is drawn up into the wound, lifting the heart with it. With

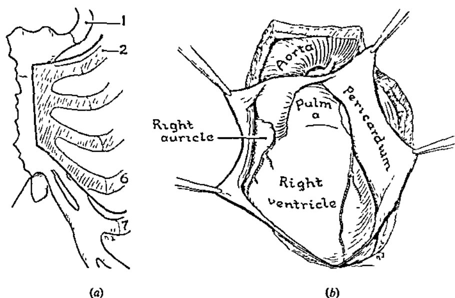


FIG 229—(a) Incision for closure of septa; (b) showing exposure of anterior surface of heart and great vessels using opened pericardium as a hammock.

counterbalancing of these forceps, the pericardium is held up in the field very nicely, and it requires only slight retraction on the bent ribs to give adequate exposure. As soon as the heart is exposed, it is sprayed with ½ per cent Novocain solution, which, it will be observed, quickly causes blanching of the epicardial surface. *Exposure of heart*

A "swedged on", No. 1 catgut suture is passed through the tip of the left ventricle to act as a retractor to bring the heart forward when the posterior surface is to be inspected. In the typical interventricular septal defect, the right ventricle is very large and lies almost entirely in front, leaving the left ventricle entirely posterior. The right auricle may be somewhat enlarged and projects to the right and posteriorly, overlapping to a degree the inferior and superior venae cavae.

The principle of the operation is to pass a living suture in one, two or more strands through from before backwards in the line of the septum, to fill in, and partly occlude, the opening by the bulk of the sutures. In addition, with slight traction, the hiatus is compressed slightly from before backwards. Also, on experimental evidence, it is demonstrated that such sutures placed in this position tend to produce thrombosis and clotting which still further tends to occlude the hiatus. To prevent excessive thrombus formation and possible embolism, heparin solution is given later on, during the first or second days, and under its influence healing of the thrombus already in place occurs. *Principle of operation*

It is necessary, therefore, to know what are the surface markings on the ventricles which delineate the site of the opening in the septum. From *Surface marking*

experimental work (Murray, 1948), it was demonstrated that a site distal to the annulus fibrosus and to the right of the descending branch of the left coronary artery will mark the anterior position for the insertion of such sutures (Figs. 230 and 231). On the posterior aspect, a point distal to the coronary sinus and just to the left of the descending branch of the right coronary artery is the site for exit of these sutures. In this position the sutures leave the aortic, pulmonary, mitral and tricuspid valves and the auriculo-ventricular bundle of His undamaged.

Palpation of heart

A strip of fascia lata 1¼ inches in width is removed from the thigh. It is tapered at one end and this is sewn on to a double strand of No. 1 silk, which silk is then threaded through a needle of suitable length to pass easily through the heart to be dealt with. This may be from 2½ to 4 inches in length. The needle is passed through eye first at the anterior site mentioned. When it has passed through the muscle, holding this needle as a probe, the interior of the heart is palpated. Without difficulty one can feel the hiatus and its margins, and the

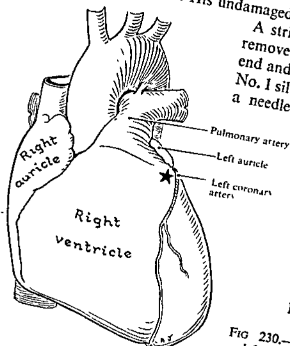


FIG 230.—Closure of interventricular septal defect. Anterior surface of heart. Star shows site at which suture enters

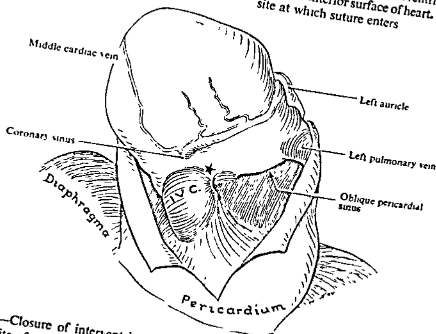


FIG. 231.—Closure of interventricular septal defect. Posterior surface of heart. Star shows site of exit of fascial suture, the area is demarcated by coronary sinus, inferior vena cava and right pulmonary vein

needle is then passed on gently until the posterior margin of the hiatus can be felt. When this has been done, the needle holder is again applied, and with the heart turned forward by traction on the apex and with the index finger over the heart muscle posteriorly, the blunt end of the needle can be felt through the heart muscle. It is directed to the posterior site already laid out and is thrust through the heart muscle at this point. Both the anterior and posterior points of approach have been infiltrated in the subepicardial area with ½ per cent Novocain. The needle is then drawn through, leaving the silk crossing the cardiac cavity and the hiatus. It is held there for a short time, and the effect on the heart action, and on the pulse rate and blood-pressure, is observed. With slight traction on the end of the silk, one can feel if the heart valves are caught up or cordae tendinae are entangled in the silk, just as one feels a trout on the end of a line. If all is clear the silk is drawn through and, following it, the living suture. Again the heart action is watched for a few minutes to note if there are untoward effects. The end of the suture on the anterior surface has had a large knot tied on it, which is then drawn down tightly against the surface of the heart and moderate tension is applied. In practically all cases, when this has been done, the enlarged right ventricle has diminished in size quite considerably, in some as much as a third, and the enlarged tense right auricle also has diminished in size, and the tension in it has diminished considerably. If there are no untoward effects, the living suture is then stitched down to the epicardium on the posterior surface while it is held under moderate tension, the anterior end is similarly dealt with. Further observations are made by the anaesthetist, and if no ill effects have occurred, the pericardium is repaired. At any stage during this procedure, should signs of danger occur, the procedure should be reversed and the suture removed without difficulty.

Closure of chest wall

The chest wall is closed, suturing the two halves of the sternum with 2 or 3 stainless-steel wire sutures; the soft tissues are closed with catgut. As a last procedure, the left pleura is emptied of blood and air by catheter and aspirating syringe.

Dressings

Light dressings are applied and the patient is placed in an oxygen tent. The intravenous Novocain is discontinued when manipulation of the heart has been completed.

(6) Complications

A small series of patients has been operated upon with a mortality rate of 25 per cent. There has been no operative mortality, but there have been unexplained deaths post-operatively. In one there was an os commune in which both auricles and ventricles communicated and there was a continuous valve cusp from the mitral to the tricuspid through this opening. Also the patient had a congenital atelectasis of the left lung and it was thought that the pneumonic process in this had caused the death on the fifth day. Until this time the heart action had seemed to be good throughout.

(7) Results

The patients have shown improvement following operation. The cyanosis has disappeared. There is greater vigour and the parents have stated almost unanimously that the children are quite different, with more energy, and take

part as do normal children in ordinary sport and play. In some patients the loud cardiac murmur before the operation has disappeared, in others it is changed and markedly diminished. Further evidence was obtained on re-catheterization of these hearts following operations. The blood oxygen contents and blood-pressures obtained indicated in some that the shunt was cut off and in others that it was diminished when compared with the pre-operative values; also, skiagrams taken following operation, when compared with those

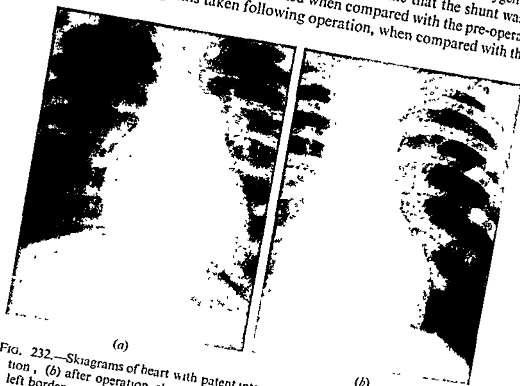


Fig. 232.—Skiagrams of heart with patent interventricular septum: (a) before operation, (b) after operation, showing change in size and shape of heart, particularly left border.

taken before, showed diminution in the size of the heart and improvement towards a more normal shape (Fig. 232). The results seem to be well wor- while, considering the clinical improvement.

6. PATENT INTERAURICULAR SEPTUM

The division of the single auricle by the ingrowth of a septum developing from the cardiac cushions is complete about the fourth week of intro-uterine life except for a fairly large opening close to the lower border, at which point it is attached to the annulus fibrosus. This opening, known as the foramen primum, persists until about the thirty-fifth day when it gradually closes. At this time the septum higher up becomes perforated to form the foramen ovale. The septum should therefore be complete, leaving only the foramen ovale by the fortieth day. If, during this time, development is arrested, the foramen primum may persist, creating what is known as the patent inter-auricular septum (Fig. 233). This opening may be so large that there is practically no sign of a septum between the two auricles, or it may be a small opening which is of little significance. The opening, however, which is found clinically, varies from probably an inch in diameter to almost a complete

absence of the septum. The patent foramen ovale is rarely a large opening, and, although it persists in about 25 per cent of normal hearts, it is of no *Patent foramen ovale*

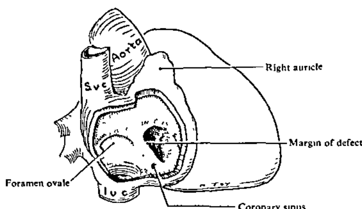


FIG. 233.—Interauricular septal defect seen through right auricle. The author's method of closure is by approximation of anterior and posterior walls of auricles to form a new septum. Cohn's method is to sew the right auricular appendage in the opening.

clinical significance in most, because of its small size and because it is partly occluded physiologically, by valves remaining from the septum secundum.

(1) Symptoms

Complete absence of the interauricular septum is compatible with life, but the circulation is defective, because the blood returning from the lungs to the left auricle tends to flow through the septum, only a part being delivered into the left ventricle and a larger proportion flowing through the patent septum into the right auricle, from whence it is again circulated through the right ventricle and pulmonary system. As a result, the right auricle is enormously enlarged, as is also the right ventricle, to accommodate the double supply of blood coming from the venae cavae as well as from the left auricle. These children are not cyanosed, as a matter of fact much of the blood is circulated twice through the pulmonary vascular tree, insuring against cyanosis. In later stages, if cardiac failure appears, the flow through the patent septum may be reversed and cyanosis will appear. The child is moderately under-developed in severe cases, has relatively little energy and has marked dyspnoea on exertion. The auricle may be so large that it may compress and displace the oesophagus, causing dysphagia, and there may be distortion of the hilum of the lung, with atelectasis. Rarely do these patients get bacterial encarditis, but they are predisposed to repeated pulmonary infections and pneumonia. *Blood circulation* *Cyanosis*

(2) Examination

There may be bulging of the precordium with a soft thrill over the upper sternal area. There is a systolic bruit, or occasionally a continuous one is heard over the base of the heart region. This is one condition which may give a prolonged bruit, having a systolic and diastolic element which differs from that of the patent ductus arteriosus. The bruit is also heard in the interscapular region. In the patent ductus arteriosus, the continuous murmur *Heart sounds*

has a fairly uniform quality except for a diminuendo toward the end of diastole.

Radiographic examinations X-ray and fluoroscopic examinations show an enlarged, globular heart with an apparently very large right side which is composed chiefly of the right auricle (Fig. 234). The enlargement is slightly more cephalic than is an enlargement of the right ventricle alone. The heart tends to be globular in shape with a very large bulge on the left border immediately below the aortic area. Well-marked pulsation of this enlargement to the right side is seen on the fluoroscope. The hilar regions, however, do not pulsate forcibly. The vascular markings in the lungs are greatly increased. Barium in the oesophagus may show displacement to the right, curving widely off the midline position. In the transverse view, the oesophagus may be greatly compressed by the enlarged auricles, there being no visible space between the posterior aspect of the heart and the anterior surface of the vertebral column.



FIG 234 —Skiagram of heart with interauricular septal defect verified at post-mortem examination

Cardiac catheterization

Pressure and oxygen content Catheterization gives very valuable information. The pressure and the oxygen content of the superior vena cava is low when compared with that of the right auricle as the catheter descends through this cavity. This variation may be a six-point rise, which is proof of oxygenated blood from the left auricle passing through a patent septum into the right auricle. The right ventricular oxygen is similar to that of the auricle and the pressure may be slightly above normal. The catheter may be found to pass freely through the interauricular septal defect, and with luck may pass into a pulmonary vein, well out in the lung fields, which again is further proof of the presence of a patent septum. In 50 per cent of the cases examined, the interauricular septal defect is combined with an interventricular septal defect, but the latter defects have been small and of little significance. However, it adds some confusion and after closure of the interauricular septal defect there may still be a persisting bruit from the interventricular defect.

Angiocardiography Angiocardiography with Diodrast may help in the diagnosis.

(3) Indications for operation

Enlargement of the heart Interauricular septal defects may be compatible with fairly normal longevity provided the opening is not too large and is not causing too great an enlargement of the heart. If, however, the opening is very large and causing great

enlargement of the heart, it may cause cardiac failure in early youth. Some of the worst cases do not survive childhood.

(4) Treatment

Apart from operative treatment, the child can only be protected from strenuous exertion and a vigorous life, and special care should be taken to avoid or to treat promptly any respiratory infection.

(a) *Operative measures*

There is the ingenious method of closure of experimental septal defects in animals, described by Cohn (1947) of San Francisco, whereby the tip of the left or the right auricular appendage is invaginated through the auricle and pressed through the defect. The tip of the auricle is then sutured to the septum surrounding the opening, and with a snare the tip is cut off and left plugging the opening in the septum, while the opening left in the auricle is closed by a running suture. This works well experimentally (Murray, 1948), and has been applied to patients.

The author's efforts at repair followed a great deal of experimental work (Murray, 1938) whereby it was possible to outline by surface markings the attachment of the septum between the auricles. By passing mattress sutures from the transverse sinus behind the aorta through to the posterior aspect of the auricles in the line of the septum, it was possible to approximate the anterior wall to the posterior wall of the auricle. This, in congenital defects, has two advantages: first it occludes the opening in the septum and, secondly, bringing the anterior to the posterior wall diminishes the size of the greatly enlarged auricles and immediately overcomes, in part, one of the bad results of the patent septum (Murray, 1948). *Approximation of auricular walls*

The anaesthetic used in these patients is similar to that used in the other cardiac operations, including intravenous injection of Novocain, 0·1 per cent, liberal spraying of the heart when the pericardium is opened, and injection at the site of entrance of the needle with Novocain, 1 per cent. *Anaesthesia*

An exposure similar to that described for patent interventricular septum is used. On opening the pericardium, inspection of the heart reveals an enormously enlarged right auricle, which has rotated the heart to the left so much that the right ventricle lies entirely in front and the left ventricle entirely behind or slightly to the right. The auricle in the five cases on which I have operated has been as large as the combined remaining chambers of the heart. It extends downward, bulging over the inferior vena cava, and the upper part bulges in such a way as to overlap the superior vena cava and thereby completely fills the pericardium in its right half from top to bottom, the right auricular appendage being about ten times the size of the left. *Enlargement of right auricle*

This rotation to the left, because of the enlarged right auricle, brings the pulmonary artery to the left and the aorta to the right when looked at from the front. It also brings that portion of the transverse sinus which would normally be behind the aorta well out to the right side of this structure, making it very easy of access from the right side of the aorta. Threaded with No. 3 silk, linen or cotton suture, a fairly large needle is passed, eye first, from the right of the aorta in the transverse sinus, through the wall of the auricle. When it has gone through the anterior wall, the needle is taken in the fingers *Method of suture*

and the interior of the auricle is carefully palpated. If there is any septum it may be felt and the position for the sutures can be determined. The needle is again grasped with a needle-holder, and by means of the suture through the apex of the left ventricle, the heart is brought forward. The needle is pressed against the posterior wall of the auricle where it is palpated through the wall with the finger and is directed to the point between the site of entrance of the right inferior pulmonary vein into the left auricle, and the point of entrance of the inferior vena cava into the right auricle. It is then thrust through the posterior wall at this point and the suture drawn through. Another suture is passed beginning about half an inch from the first and coming out a similar distance from the first posteriorly. One, two or three more sutures may be passed in the line of the septum in similar fashion, all coming out posteriorly. These sutures are tied one to the other on the posterior aspect. When this has been accomplished, there are mattress sutures crossing the auricle. With slight traction from the front, and compression by the finger, the anterior wall of the auricle can now be pressed back to meet the posterior wall which is drawn forward by the sutures. In this way the two auricles are separated from each other by apposition of the anterior and posterior walls. The right auricle immediately diminishes to a half or less of its original size. The auricular appendage shrinks down and the pressure in the auricle diminishes The right ventricle, which is enlarged and under considerably increased pressure, also diminishes in size and the pressure is diminished. The patient's general condition may show no change during the operation. There may be a few extrasystoles but no other change in rhythm or other alarming effect. In fact the result has been one of almost immediate improvement of cardiac function.

Apposition of auricular walls

The essential feature, perhaps, in performing this operation is to be aware of the fact that the congenital heart is not a good functioning organ at the beginning. It must be handled gently and when the tip is drawn forward to expose the posterior surface it must not be held for too long, because within three or four beats there is evidence of cyanosis and some further dilatation of the right ventricle. It is essential, therefore, for the operator to keep a weather eye on the heart, looking for these effects, and at short intervals to allow the heart to go back into its normal working position. The operation must, therefore, be done in short relays.

Precautions

Observing these precautions, I have had no disasters or deaths on the operation table. As a matter of fact, with one exception, the cases of closure of the interauricular septum, being five in number, have survived the operation, are still alive and well and are improved (Fig. 235). Patients whom the parents stated were semi-invalids and weakly have gained normal strength and vigour.

Results

(*b*) *Future trends*

Efforts have been made by Crafoord, Stubbins, the author and others to short-circuit the circulation through the heart while still keeping up the coronary and cerebral blood-pressures. Under these conditions the heart can be opened and a direct approach made to these septal and valve defects, when direct repair with foreign material or transplanted grafts can be carried out. While unquestionably this will be accomplished in future with safety,

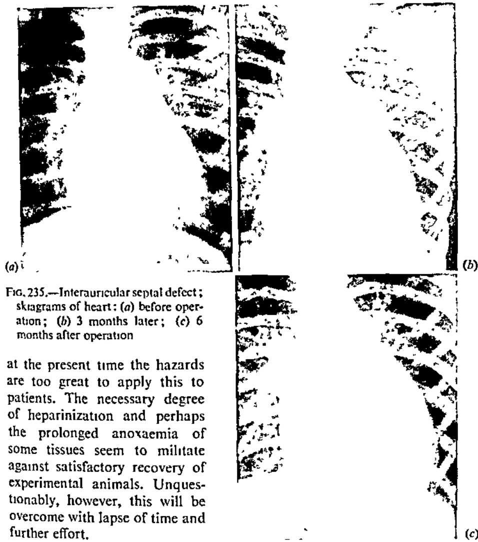


FIG. 235.—Interauricular septal defect; skiagrams of heart: (*a*) before operation; (*b*) 3 months later; (*c*) 6 months after operation

at the present time the hazards are too great to apply this to patients. The necessary degree of heparinization and perhaps the prolonged anoxaemia of some tissues seem to militate against satisfactory recovery of experimental animals. Unquestionably, however, this will be overcome with lapse of time and further effort. *Hazards*

7. CARDIAC ISCHAEMIA

In this section, drug therapy or operations dealing with the cervical or dorsal sympathetic nerve supply will not be considered. The plan is to deal only with methods of surgical treatment in which direct operative attack is made either on the heart, on its coronary vessels or on the immediate nerve supply in relation to the heart.

Collateral circulation to the heart

The conception of the blood supply to the heart entering through a pedicle at the base, suggested that circulation from another source across the epicardium might provide a collateral which would be useful when coronary circulation was impaired or occluded. The author's (Murray, 1938) experimental work on this was done in 1932 and later similar work together with its clinical application on patients was reported by Beck and Tichy (1935). *Experimental work*

(*a*) *Vascular grafts*

My efforts (Murray, 1947b), which were similar to those used since by

many experimenters, were to apply to an area of the heart surface, either before or after occlusion of a branch of the coronary artery, a vascular graft, such as a portion of the diaphragm, triangularis sterni, pectoralis, omentum or other vascular tissue. It was found after a time that the coronary arteries supplying an area covered with such a graft could be tied off and the animals survived, whereas a large proportion of the controls did not.

Production of pericardial adhesions

Severe excoriation of the surface of the heart and the pericardium with the object of producing adhesions was also tried. Later on, Beck added the principle of applying an abrasive substance, such as ground-up bone or sharp metallic or calcium substance, to produce pericardial adhesions. Beck has operated upon a group of patients and has found that they are moderately improved, but the end-results have still to be assessed.

(*b*) *Anastomosis*

Coronary occlusion

Beck's recent work, similar to that of Blalock and Sinstrom, is to anastomose to the coronary sinus a large branch from the aorta, or an intervening graft to conduct blood from the aorta to the coronary sinus. In about 450 experimental animals, Beck is convinced that, following coronary occlusion, there is some improvement in cardiac circulation and function by reversing the flow through the coronary sinus in this way. However, Blalock in a discussion of this paper was not enthusiastic and felt that thrombosis of the venous vascular tree in the heart, thrombosis at the site of anastomosis or aneurysmal dilatation of the coronary sinus was apt to occur, especially if the sinus was tied off distal to the site of the anastomosis. If, however, the sinus is left open, these effects may not occur but circulation through the heart is not materially improved. Fauteux, entertaining similar ideas regarding the function of the coronary sinus, felt that by tying it off there might be improvement of the cardiac circulation following coronary ischaemia, and he has operated upon a large number of animals and a few patients in whom he is satisfied that there is some improvement following his operation.

(*c*) *Sympathectomy*

Fauteux also has done sympathectomy of the coronary artery involved in the sclerosis or occlusion, with what he considers to be a good result. This sympathectomy was done on some occasions by resection of the adventitia and in other instances by applying a sclerosing solution with the object of interrupting the sympathetic nerve supply to these areas.

(*d*) *Resection*

The author, assisted by Janes and McGregor, did further experimental work on coronary occlusion, involving resection of a portion of the coronary artery and either doing an end-to-end suture or placing in a venous graft. It was shown that when the site of injury of the coronary artery was resected and the continuity of the artery restored, cardiac infarction did not cause death in as large a proportion of animals so treated as compared with controls.

Another phase of experimental work on cardiac ischaemia, published by the author (Murray, 1947b), probably contributes to the conception of how coronary occlusion produces its effect on the general circulation. It was demonstrated that very soon after coronary occlusion there is lack of

contraction, and eventually marked bulging at the site of the future infarct. This expansion chamber receives a greater or lesser proportion of the ventricular blood on systole, so that the left ventricle is unable to deliver its usual quantity of blood into the aorta. This expansion-chamber effect, labelled paradoxical systole, accounts for the period of lowered blood-pressure and the symptoms of shock which are characteristic of a severe coronary attack. It also may be the focus from which may come the stimulus causing ventricular fibrillation (Beck and Tichy, 1935). *Paradoxical systole*

These effects are the result of the lack of delivery of a sufficient quantity of blood into the systemic circulation because of the expansion chamber. It was demonstrated that when this expansion chamber was large, causing greater embarrassment and diminished efficiency of the left ventricle, the blood-pressure was lower, and over a period of time it tended to fall still farther until eventually the heart was unable to keep up the circulation. The ultimate effect may be ventricular fibrillation, which is only a terminal episode.

Experimentally we showed that if the expansion chamber is prevented from forming, these effects on the general circulation do not occur. Secondly, if within a short time of occlusion of a major coronary artery the area to become infarcted is underpinned with mattress sutures and the infarcted area excised, the falling blood-pressure with diminished output can be prevented and the animal will survive. It would appear, therefore, if this is true, that the treatment of shock by transfusion and similar measures is of little value and is not directed toward the defective mechanism causing the failure in coronary occlusion.

Although resection of the infarcted area is not advocated at the moment as the first method of treatment for coronary occlusion, the day must be close at hand when this sort of surgical approach may be feasible, especially in those patients in whom a definite aneurysm of the ventricular wall is demonstrated.

I have done such an operation on one patient in whom there was recent coronary infarction On exposure through the incision described under Patent Interventricular Septum the pericardium was opened. It was easy to identify a soft area toward the apex of the heart on the anterior wall, which was obviously the site of the infarction. It was the typical expansion chamber seen in the experimental animals and was dealt with without difficulty. The patient stood the operation very well, but died subsequently of cerebral arteriosclerosis with cerebral softening and at post-mortem examination it was demonstrated that the heart was in good condition. The area of dissection and repair had healed satisfactorily. There were no thrombi and no aneurysm and from the cardiac aspect things had gone satisfactorily. *Results*

8. MITRAL STENOSIS

Cutler (quoted by Levine, 1936), and other investigators, divided the mitral valve in stenosis or resected portions of the valve, hoping to relieve the back pressure on the left auricle and improve cardiac function. They found that either division or resection of the mitral valve added further incompetence.

It was also found by the author that if simple division was carried out experimentally and the animal survived, the valve tended to heal fairly rapidly and eventually it was back in the original state of mitral stenosis.

It would seem obvious, as the former workers had postulated, that if the mitral stenosis could be relieved, the enlarging left auricle with high pressure and eventual fibrillation, and perhaps the formation of thrombi and peripheral embolism might be relieved.

The author, with the assistance of Wilkinson and MacKenzie, in 1938 resected the postero-lateral cusp of the mitral valve in dogs, by passing a punch through the left auricular appendage. In control animals the incompetence very rapidly caused dilatation of the left auricle, cardiac embarrassment and, within a period varying from a few hours to twenty-four hours, most of these animals died. If, however, this resected valve was replaced by a new valve, many of these animals survived and had normal cardiac function and longevity.

In the new valve it was necessary to have a surface which was accustomed to living in the blood stream and would not promote thrombosis or clotting For that reason a peripheral vein, turned inside out, was used and through its lumen a tendon was passed to give it more substance. The new valve was passed through the wall of the left ventricle in such a position and with so little tension that during systole it would be thrust into the opening left by the resection of the cusp. With the slackness of the new valve during diastole, it would float out of the opening into the ventricle and would not obstruct the filling of the ventricle.

Several patients have now been subjected to the operation, in which a portion of the stenosed mitral valve has been excised with a punch, and a valve made of cephalic vein and palmaris longus tendon has been placed in the heart This has given improvement of function of the heart, diminution in size of the left auricle and a great change in the bruit compared with that heard before the operation.

Results

Although it is not known how long this may last or what the end-results may be, for the present at least the operation seems to be well worth while in selected cases. It has changed several of these patients from complete invalids, spending most of their time in bed with repeated attacks of failure, to a condition in which they are up and about, and some of them have gone back to light work. The cyanosis and attacks of failure have not returned over a period of three years.

All the patients operated upon were in an extremely bad and late stage of mitral stenosis with fibrillation. At operation it was thought that as the auricle was so large and tense, and its wall so thinned out, the resection would be best carried out through the left ventricle. For that reason an opening was made in the anterior wall of the left ventricle and the punch inserted there. The only disadvantage in this is that the opening in the valve is not so easy to find from the ventricular side as it is from the auricular side, where it tends to be cone-shaped and will direct the instrument through the opening. However, we were successful in all cases, getting the instrument through and resecting a portion of valve.

9. PULMONARY EMBOLECTOMY

Trendelenburg's contribution in opening the pulmonary artery for removal of massive emboli has not met with widespread success. The difficulty of a certain diagnosis and the many hazards of operation have given very few successful cases out of an enormous number in which it has been tried. Up to 1939 there were only eleven successful pulmonary embolectomies reported, although since that time there have been further successes.

Right ventricular approach

With the assistance of Delorme and Thomas, it was decided that the hazards of opening and closing the pulmonary artery might easily be overcome by another approach. My experiments were directed towards an approach through the wall of the right ventricle; this approach can be made without difficulty and without danger. We demonstrated that a variety of foreign bodies could be passed into the pulmonary artery and recovered by this approach, without difficulty. It was demonstrated that an instrument would go through the pulmonary conus, the pulmonary valves, the pulmonary artery and into each of its branches without any obstruction, and that if the foreign body could be brought almost completely within the nozzle of an aspirating tube, that it could be withdrawn without difficulty through this valve system. To accomplish this, an instrument was constructed in which there is a cannula with a valve; this instrument can be placed without difficulty through the wall of the right ventricle. A position is selected near enough to the base of the heart and in the region of the conus, so that the moderator band, if present, would not be injured in the approach. Through this cannula a large tube attached to an aspirating machine can be passed at will. It has a side opening to relieve the suction so that it can be passed through the valves and down the pulmonary artery into the right or left branch; by closing the opening, suction is applied, which will bring the foreign body or clot within the sucker, and the whole is then withdrawn through the cannula. The valve prevents escape of blood.

Removal of embolus

In this way cardiac action is not embarrassed, the circulation is not cut off, and one can work at ease and with leisure and not under the great strain of conditions when the circulation is closed off as in the Trendelenburg operation. This operation has been accomplished in many experimental animals and has been used satisfactorily in patients. Provided the diagnosis is accurate the operation can be carried out with ease, and one has every confidence that a good team in hospital, arriving on the scene at the right time following pulmonary embolism, with the instruments and the set-up available, could accomplish this with satisfaction and safety. If preventive measures and anticoagulants eliminate pulmonary embolism, such operations will be obsolete, but until this is accomplished, an operation such as this may be timely if a patient is dying from an acute attack (Neuhoff, 1947).

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[References to other titles are given under Vascular Surgery in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol. 6, p. 205.]

VEINS—VARICOSE

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1. DEFINITION AND PATHOLOGY

344] Varicose veins (from the Latin word *varix* meaning a dilated tortuous vein) may occur in many parts of the body. The anal canal and the spermatic cord are well-known sites for varices, and, in portal obstruction, the oesophagus and the vicinity of the umbilicus, where a so-called caput medusae *Sites*

may be formed. Only varicose veins of the lower extremities will be considered here. Such varices are most commonly a primary condition, but in some cases may be secondary to another disease such as deep venous thrombosis or arteriovenous fistula.

Histology of primary varices It has been stated that the walls of varicose veins consist of degenerate stretched fibrous tissue and that muscle no longer exists in the media. This may be so in extremely advanced cases, but evidence of such pathology could not be found in a recent histological investigation of varices removed at operation; these had no undue fibrosis in the media and the muscle appeared healthy, plentiful and in many cases hypertrophied. This suggests either that the valves are primarily at fault or that any mural fault that may exist is a physiological one such as might occur through nervous or hormonal effects causing excessive relaxation of the muscle layers.

Studies of the deep veins, in the past by dissection and in more recent times by radiological methods, have shown that superficial varices are accompanied in a proportion of cases by a similar dilatation and tortuosity of the deep venous system. It is possible that the remaining cases in which anatomical defects are not demonstrable are subject to physiological faults in the deep venous system, such as retrograde flow through incompetent valves and raised intravenous pressure. Further measurements of deep venous pressures and radiological studies of retrograde flow in the deep veins are necessary to elucidate this very important point.

Secondary varices Secondary varices occur in the lower limbs in a number of conditions which include pregnancy, arteriovenous fistula, arterial diseases and deep venous thrombosis. The last group is a large one and will be described in detail later (*see* p. 532 and p. 540).

2. CLINICAL FEATURES

Primary and secondary varices The most important step in the investigation of the patient with varicose veins is to decide whether the varices are primary or secondary, and a careful history must be taken to help to determine this. Illness, operation or pregnancy may have been followed by deep thrombosis. A penetrating injury may have caused an arteriovenous fistula. A history of spontaneous deep or superficial phlebitis may suggest thrombophlebitis migrans or Buerger's disease. Arterial symptoms such as intermittent claudication may also mean that the varices are part of a generalized vascular disease such as Buerger's disease or arteriosclerosis.

(1) Primary varices

(a) *Presenting symptoms*

Pain Pain is an inconstant complaint. It may occur as localized tingling or sharp pain in the superficial veins but much more commonly as a dull generalized ache in the leg. The last type of pain sometimes remains after the superficial varices have been adequately dealt with, and in such cases must presumably be due to inefficiency in the deep channels.

Complications In other patients the presenting symptoms are those of complications such as oedema, dermatitis or ulceration. *Unsightliness* Very often the only complaint is of the unsightliness of the varices but treatment is usually necessary even in these cases in order to prevent deterioration or the onset of complications.

(b) Examination

Anatomical The size and anatomical situation of the varices and their location on the great or small saphenous systems are noted. Assistance in deciding to which system varices in the leg belong may often be obtained by use of the palpation-percussion test (McCallig, 1946). A finger is placed upon a known tributary of the great or small saphenous vein and the varix in doubt is tapped gently with the index finger of the other hand; should the tributary be in communication with the palpated vein very distinct impulses can be felt. The percussion impulse may be felt several inches along a vein irrespective of whether the valves are competent, and it is often of greater service than observation alone in determining the anatomical situation and consequent necessary site for ligation in a patient with obese legs.

Physiological tests The names of tests for investigating the physiology of varicose veins are numerous and confusing, but a knowledge of some of them is, however, necessary, as they provide essential information. Many of these tests bearing the same name may be used in varying ways to provide different information.

Efficiency of valves In dealing with primary varices the efficiency of the valves in the superficial and communicating veins is the most important point to be determined.

Cough impulse An impulse or thrill on coughing may be felt over the great or small saphenous vein in the more marked cases of valvular incompetence.

Trendelenburg's test Lesser degrees of incompetence may be detected by Trendelenburg's test. The patient sits upon a chair and the limb is elevated to empty the veins of blood. A rubber tourniquet is lightly applied near the top of the great saphenous vein; the patient then stands up. The tourniquet is released. Rapid filling from above indicates incompetence of the valves in the great saphenous vein. Should incompetent valves exist in a communicating vein lower down the thigh (a so-called blow-out), the veins will fill rapidly before the tourniquet is released. In such a case the level or levels of "blow-outs" may be determined by repeating the test with the tourniquet applied at different levels. Very often a large localized varix can be seen at the site of an incompetent communicating vein.

The efficiency of valves in smaller lengths of vein may be investigated by applying a method similar to that used by Harvey in his original demonstration of the existence of venous valves The blood is "ironed out" of the length of the vein near a junction with another vein or a suspected incompetent communicating vein, using the index finger of each hand. The proximal finger is removed. The vein will fill down to the first competent valve or as far as the distal finger if no competent valve exists.

Marking sites for ligation The points chosen for operative ligation will depend upon the location of incompetent valves and communicating veins demonstrated by these clinical tests. It is helpful to mark with indelible ink before operation the points decided upon. There are other tests besides those described here for determining the competence of the venous valves, but, excellent though they are, more reliable information is to be obtained by habitual use of the same few tests than by using different ones on different occasions. These other tests will not therefore be described.

(2) Secondary varices

The secondary varices include the varices due to arteriovenous fistula or

to pregnancy, varices associated with general vascular disease such as Buerger's disease and arteriosclerosis, and the common varicosities following deep venous thrombosis.

Arteriovenous fistula

Those due to arteriovenous fistula are recognized by the history of a penetrating injury, the presence of scars, and the characteristic thrill and bruit.

Arterial disease

Associated arterial disease is evident from the signs and symptoms of ischaemia in the legs, prominent among which is the loss of certain peripheral arterial pulses. Varices associated with arterial disease and with pregnancy

Pregnancy

will be discussed further under the heading of Treatment of Secondary Varices (*see* p. 542).

Post-thrombotic cases

The post-thrombotic cases may be grouped as follows.

(*a*) *True compensatory veins*

The deep channels have been permanently blocked following thrombosis. The superficial varices are therefore essential channels for the return of blood from the limbs and should not be interfered with by injection or ligation.

Test of patency of deep channels

The tourniquet test for patency of the deep veins.—This test should be performed on every patient with a possible history of deep thrombosis on whom operation is being considered for varices. A rubber band is applied to the upper one-third of the thigh sufficiently firmly to occlude the superficial veins. The patient then walks about briskly; should the deep channels be blocked pain will very soon be experienced and the superficial veins will be seen to become congested. If the patient can walk without pain for 10 minutes it can be safely assumed that the deep channels are patent.

(*b*) *Post-thrombotic incompetence of deep valves*

The deep channels may recanalize leaving the valves incompetent. In such cases the tourniquet test of deep patency does not cause pain although the superficial varices may become distended when the patient walks. A modification of the Trendelenburg test described by Linton and Hardy (1947) is often helpful. The limb is elevated and a tourniquet is applied below the knee to occlude the superficial veins The patient stands. Incompetence of the deep valves is indicated by rapid filling of the varices below the tourniquet.

Linton's test of deep valvular competence

(*c*) *Persistent superficial varices with deep veins returned to normal*

Very often patients with superficial varicose veins give an undoubted history of deep thrombosis, but on investigation the deep veins prove to be patent and are found to have competent valves It must be presumed that the thrombosis, probably a mild one, has resolved without permanent damage to the valves The treatment is similar to that for primary varices.

3. SPECIAL INVESTIGATIONS

(1) Phlebography

Following the clinical investigations described, doubt may still exist as to the patency of the deep veins. In such cases phlebography is helpful. The method described here is a simple one which can be used with standard instruments in the operation theatre, using a portable x-ray machine. For the exceptional case where a larger extent of limb requires to be x-rayed in greater detail, methods requiring special cassette tunnels and facilities for x-ray examination of leg and thigh in rapid succession are necessary.

A hollow needle (S.W.G. 21) is inserted into a vein on the dorsum of the foot; should this prove impossible a small incision is made and a cannula, such as may easily be made by filing the sharp point off a needle, is tied in place in a vein. Local or general anaesthesia may be employed; 15–20 cubic centimetres of 50 per cent diodine (the least irritating preparation of which is Pyelosil) are injected steadily over a period of 50 seconds. A pneumatic cuff inflated to a pressure of 40 millimetres of mercury applied at the ankle prevents passage of the dye through any channels except those deep veins lying between the tibia and fibula. A skiagram is taken using the maximum size of film placed diagonally so that the longest extent of deep veins in calf, popliteal fossa and thigh is reproduced.

Simple routine method

Anaesthesia

(2) Manometry

Superficial femoral vein ligation may be considered in cases with incompetent deep valves; the pressure in the temporarily occluded vein should be measured before it is finally ligated. The technical details will be described when the treatment of the post-thrombotic syndrome is considered (*see* p. 541).

Femoral vein ligation

4. TREATMENT OF PRIMARY VARICES

(1) Rationale

A method of repairing inefficient veins or valves has not yet been devised, so that the chief object of treatment is still obliteration of inefficient channels, leaving the more healthy ones to carry the blood. It is important that this obliteration should take place without damaging the healthier channels, whether deep or superficial, as may frequently have occurred in the past when injection methods were used blindly. Recent experimental work (Boyd and Robertson, 1947; Kinmonth, 1948) suggests that the methods of injection therapy in present use should be revised, and it will therefore be outlined before proceeding further. The investigations fall into two groups

Obliteration of diseased veins

(*a*) *Phlebographic investigations of the fate of injected fluid*

Phlebography

Imitation of some common types of injection using a radio-opaque dye has brought the following points into prominence.

(1) Retrograde injection down the great saphenous vein at operation as commonly performed is an inaccurate method, because much of the fluid passes rapidly onwards into communicating, deep, or even healthy

Retrograde injection



FIG 236—Phlebogram showing the effect of injecting 4 cubic centimetres of fluid through a catheter passed down the great saphenous vein at operation. Most of the fluid has passed at once into the deep channels.



FIG. 237.—Similar procedure to that in Fig. 236 but with 3 cubic centimetres of fluid injected while withdrawing the catheter Again much dye has passed into the deep channels



FIG. 238.—Phlebogram taken at completion of injection of 2 cubic centimetres of dye Even this small amount has overflowed into the femoral vein.

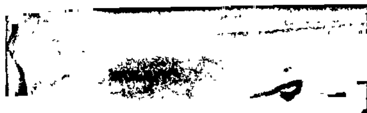


FIG. 239.—Phlebogram of injection of 1·5 cubic centimetres into varix with the limb horizontal.

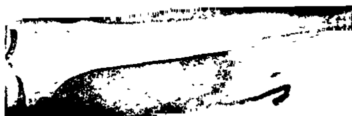


FIG. 240.—The same injection as in Fig. 239 but 2 minutes later The patient has not moved his leg and the fluid remains where injected.

Choice of case

investigations to possess grave disadvantages. Certain types of varicose vein are unsuitable for treatment by injection: these include the groups of extremely narrow radiating veins sometimes described as "*spider bursts*" and any veins which are too small to be entered by a needle without difficulty or risk of perivenous injection. In other patients, for one reason or another, any form of operative or injection treatment may be contra-indicated and palliative measures are required; these measures will be discussed later. It follows that all remaining types should be treated by injection, with or without operation (the technique of injection is the same in either case).

Operation is unnecessary if the valves are competent in the great saphenous vein in the thigh or in the upper part of the small saphenous vein at the back of the calf.

(i) *Empty vein technique.*—An empty vein technique based on experimental findings which gives good results is the following. The patient lies upon a trolley or operation table with a pneumatic tourniquet cuff on the thigh. A good light is essential. The tourniquet is inflated and the needle is inserted into the distended varix; the cuff is then deflated and the injection made when the vein has collapsed. The best volume of sclerosing fluid to use is 1·5 cubic centimetres, and a fluid should be used which has the greatest effect for its volume. Ethamolin, which causes little damage if inadvertently injected outside the vein, has been found to be most generally useful. The patient should remain lying with the limb quite still for 5 minutes after the injection, and then the limb should be exercised vigorously to sweep the fluid on to be diluted in the general circulation.

(ii) *Antiseptic precautions.*—Too much stress cannot be laid upon the necessity for careful precautions to prevent sepsis. In otherwise excellently organized clinics such arrangements too often are lax. Cases of septic phlebitis and even septicaemia or pyaemia have been recorded following the introduction of dirt and micro-organisms, which causes, although rare, have been none the less tragic and in most instances avoidable. The area surrounding the point of injection should be extensively shaved, and cleaned with soap and water or a suitable cleansing antiseptic such as Cetavlon.

Test injections

(iii) *Reactions.*—Patients exist who react excessively with over-extensive and painful phlebitis to injections in amounts which are quite suitable for the majority of subjects. Such patients are often women or old people with large and thin-walled varices, and they frequently describe somewhat startling or painful results from past injections. It is wise in these circumstances to give a small injection, ¼ or ½ cubic centimetre of Ethamolin, as a test injection, and to inspect the site 24 hours later. From the reaction produced it can be decided whether the customary dosage can be employed or whether smaller and more cautious injections should be performed.

(iv) *Organization.*—Efficient organization is necessary to save time in a busy clinic where many patients require treatment. It is useful to have at least 2 trolleys available. The first patient after injection is wheeled from under the light and may lie still for 5 minutes while a second patient on another trolley is wheeled under the light and injected. It is advantageous to have more than one tourniquet and each should be large enough to be used upon the thigh. Suitable cuffs can be made by sewing two of the smaller type of bag, usually used upon the arm, end to end.

(*b*) *Operation*

Choice of patient

Patients who are found to have incompetent valves in the great saphenous system in the thigh, or in the small saphenous system in the upper part of the calf, require operation, combined in the great majority of cases with injection treatment. It is useless to attempt to treat such patients by injection alone because the pressure in their superficial veins is so much increased that it is difficult to procure good obliteration, and even should the attempt be successful further varicosities soon appear in the neighbouring and previously normal veins.

Choice of anaesthetic

Local anaesthesia allows the patient to walk or to exercise the limb at the end of the operation and thus reduces the risk of deep thrombosis through stasis. Operation should, however, be performed only under good conditions, with the limb adequately shaved and prepared, otherwise sepsis and delayed healing will ensue It is in fact wise to admit these patients to hospital for a few days for their operations. If general anaesthesia is employed it should be of a type which allows the patient to recover consciousness rapidly and must be followed by early ambulation to prevent deep thrombosis. Coincident injection should only be performed if particular measures are taken to prevent sclerosing fluid remaining long in the sluggish circulation of the lower extremity.

Site of ligation

Patients with incompetent valves in the great saphenous system in the thigh require high ligation of the great saphenous vein at its junction with the common femoral vein If other incompetent communicating veins exist, ligation is also necessary at points lower down the thigh or at knee level.

High saphenous ligation

High ligation at the sapheno-femoral junction will be described first. This operation is customarily named after Trendelenburg, although he did not in fact stress such a high site for ligation.

The incision

The incision is made in line with the skin fold of the groin, in order to procure healing with a minimum of scarring. It is centred over the point where the great saphenous vein passes through the fossa ovalis of the deep fascia to join the common femoral vein; the surface marking for this point lies 1¼ inches below and 1½ inches lateral to the spine of the pubis, which is readily palpable. As an additional check it is helpful to palpate the femoral arterial pulsations below the inguinal ligament; the common femoral vein and the centre of the incision will lie just medially.

Obesity

In fat patients where landmarks are felt with difficulty it is best to place the incision a trifle lower, so that the great saphenous vein cannot be missed, and to make it somewhat longer so that the vein may be followed upward to its junction with the common femoral vein by retracting the upper edge.

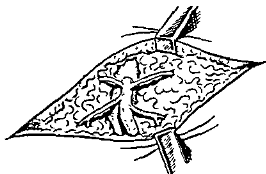


FIG 242.—Sapheno-femoral junction defined at operation.

The incision is carried down to the great saphenous vein with light strokes of the scalpel which is then

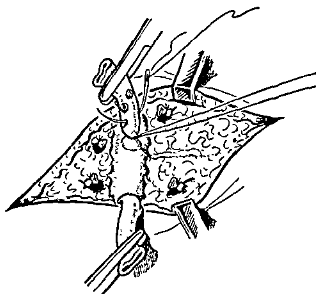


FIG. 243.—Ligation of saphenous vein at its junction with the femoral vein.

laid aside; further dissection of the *vein and tributaries* is performed with Mayo *scissors until* the upper 1½ or 2 inches of vein up to its *junction* with the common femoral vein are defined (*Fig.* 242). *All* the tributaries, which vary from 1 to 5 or more in number, are ligated and divided. The great saphenous vein is then ligated flush with the common femoral vein and divided (Fig. 243). The lower edge of the incision is retracted downwards and the great saphenous vein is ligated and divided once more, the intervening portion being removed. Haemostasis is completed and the wound is closed. One or more vertical mattress sutures may be necessary in fat subjects to avoid leaving a subcutaneous dead space. Careful and accurate apposition of the skin edges is essential to ensure primary healing.

Ligature flush with common femoral vein

It was thought at one time that the *fons et origo* of increased pressure in the great saphenous system lay at the sapheno-femoral junction, and consequently that any recurrence after operation was due to failure to ligate the saphenous vein flush with the femoral vein, so that collateral channels consequently replaced the original vein. Such cases occur, but there is no doubt that failures also follow the operation when it has been quite punctiliously performed; these failures are due to incompetent communicating channels between deep and superficial systems lower down the thigh. Incompetent communicating veins which have been localized, as already described, during the physical examination of the patient, must be dealt with at operation.

Communicating veins in thigh

Triple ligation

Each "blow-out" is dealt with by triple ligation of the communicator and of the great saphenous vein above and below it, and by excision of the intervening portions of veins. This can be done through short incisions placed longitudinally over the course of the great saphenous vein, which should also be interrupted at knee level. Each incision is closed with interrupted stitches and covered with a small sterile gauze dressing kept in place by Elastoplast. These dressings are left in place until the eighth postoperative day, when the stitches are removed. The patient is allowed to walk immediately after operation.

Injection of varices in leg

Injection of varices in the leg will be necessary in many patients, and this is best done in about 2–3 weeks' time, using the empty vein technique already described. Should such postponement be inconvenient for any reason the varicosities may be injected at the end of operation, the limb being kept still for 5 minutes after injection and then moved and the patient made to walk. If general anaesthesia has been employed and injection

performed at the end of operation, it is even more important to avoid any stasis of sclerosant in the veins of the lower extremity. Five minutes after injection the limb is elevated and the veins are massaged to push the injected fluid onwards to dilution in the general circulation. The procedure of choice, though more time-consuming, is operation under local anaesthesia with injection at a subsequent date.

Small saphenous vein ligation

Incompetence of the valves in the upper part of the small saphenous vein may necessitate its interruption. The patient lies upon his face and a short tranverse incision in line with the skin folds is made over the vein where it is about to pierce the deep fascia to join the deep system of veins in the popliteal fossa. Retrograde injection of this vein must never be performed: phlebography has demonstrated its extreme inaccuracy. The varices in the calf are best dealt with by direct injection with a needle, using the empty vein technique, and preferably some 2–3 weeks after operation.

Periodic review

It is well to review most cases of varicose veins 6 months after treatment is complete; further varices often develop through degeneration of healthy veins or even through recanalization of thrombosed varices. An intelligent patient may be told to regard his veins in the same way as his teeth, which require examination and attention at suitable intervals.

(*c*) *Palliation*

Palliative measures are necessary in a minority of cases of primary varices, usually because the patients, through age, infirmity or some coexistent disease, are unfit for treatment by injection or operation. Such patients must avoid prolonged standing and must sit with their legs horizontal whenever possible.

Elastic bandages

Elastic bandages should be worn during the daytime and the two-way-stretch variety is best, as it does not produce constricting ridges behind the knee when it is flexed. The bandages should be carefully applied, starting below near the toes and proceeding upwards to the knee or beyond. The bandages must be renewed when elasticity is lost.

Stockings

Elastic stockings are in many ways better than bandages, but it is essential that they are well made to fit without undue constriction or looseness. The patient should have several pairs so that the legs are not without support for periods during which bandages or stockings are being laundered.

Care of skin

To prevent eczema and ulceration the skin of the legs must be kept scrupulously clean by regular washing with soap, tepid water and a soft flannel. After gentle drying lanoline should be applied.

Palliative treatment may also be necessary for varices appearing in pregnant women or in patients with peripheral arterial disease. The management of these cases will be discussed under the heading of Treatment of Secondary Varices (*see* p. 542).

(3) Complications

Prophylaxis

Complications may result from the disease itself or may follow treatment. In the former class are found oedema, eczema, ulceration, haemorrhage and phlebitis; most of these result from neglect and the best treatment for them is prevention by the measures described for the management of primary varices. Some patients when first seen have already developed the complications. In addition to treating the varices in the usual way, patients with

Oedema
Eczema

oedema will require supportive measures such as bandages, and those with eczema will need protection of the skin. If desquamation has occurred, applications of a bland ointment such as zinc oxide are necessary.

Ulceration

Ulceration always suggests incompetence of the deep valves, often of post-thrombotic origin. Such patients must be admitted to hospital and operation or injection postponed until the ulcer is healed or at least cleared of infection by rest and by application of antiseptic dressings appropriate to the sensitivity of the organisms concerned.

Haemorrhage

Profuse venous bleeding sometimes follows injury to a large distended varix. This is easily arrested by placing the limb horizontal and applying a dressing and a firm but not tight bandage.

Superficial phlebitis

Phlebitis may be superficial or deep. The former is best dealt with by application of a pad and bandage and by ambulation. The patient must on no account remain in bed, and injection therapy is avoided until all trace of the phlebitis has subsided. Frequently such a process results in natural obliteration of diseased veins.

Deep phlebitis

Deep phlebitis is treated in the usual way with anti-coagulant therapy, for details of which the appropriate section of this work should be consulted (*see* Coagulants and Anti-coagulants in Vol. 3, p. 76).

Complications of treatment

The commonest post-operative complication is wound sepsis, which should be treated by removal of stitches and exhibition of antiseptics appropriate to the sensitivity of the organisms concerned.

Deep phlebitis after treatment can be prevented by taking the precautions already described in connexion with injection technique, and particularly by avoiding mass retrograde injection at operation.

Extensive painful superficial phlebitis is most often the result of too large an injection of sclerosing fluid and is most likely to occur in old patients, particularly women with advanced disease, or those with a history of spontaneous phlebitis. Such patients must always be treated with great caution and a very small test dose should be given before injection in therapeutic amount is performed.

Reactions to injection

The majority of so-called reactions to injection, such as fainting attacks, are of functional origin, for they frequently occur after the needle is inserted and before any fluid has been injected, particularly when the procedure is performed with the patient standing. True reactions to Ethamolin in the small dosage recommended are extremely rare; should they occur further injections are not advisable.

5. TREATMENT OF SECONDARY VARICES

(1) Post-thrombotic varices

Most secondary varices are the aftermath of deep thrombosis, and may be divided into three groups, first, those with a persistent deep block, secondly, those with patent deep channels but incompetent valves, and thirdly, deep channels restored to normal but with persistence of the superficial varices (*see* p. 532).

(a) *True compensatory veins*

Recanalization has failed to occur and a permanent obstruction persists in the deep channels. The tourniquet test has resulted in pain and perhaps a phlebogram has been performed to demonstrate the obstruction. No attempt

should be made to obliterate these superficial varices and only palliative measures, such as the use of a supporting *crêpe* bandage or elastic stocking, should be adopted. *No obliterative measures*

(*b*) *Incompetent deep valves*

Incompetent deep valves are diagnosed by the clinical tests already described, and a phlebogram shows patent deep channels. The subinguinal confluence of veins in the femoral triangle should be explored and the effect of temporary obliteration of the superficial femoral vein should be tested by manometry. The exploration is performed through a vertical incision centred about 3 inches below the inguinal ligament in the line of the femoral vessels. A transverse incision would give insufficient access. The great saphenous vein is followed to its termination in the common femoral vein which has been formed a short distance inferiorly by the junction of the superficial and deep femoral veins. All four veins are identified and the superficial femoral vein is dissected with great gentleness from the artery for an extent sufficient to pass a narrow tape around the vein, so that it may be temporarily obliterated by a single knot over a small piece of rubber tubing (Fig 244) A needle is inserted into the superficial femoral vein distal to the ligation and the pressure is measured with a spinal manometer containing saline solution (Fig. 244) Linton advises that ligation of the superficial femoral vein should not be performed if the pressure rises to 30 centimetres of water when it is occluded (Linton and Hardy, 1947). In such a case it may be of benefit to ligate the great saphenous vein in the manner employed in the treatment of primary varices *Subinguinal exploration* *Manometry*

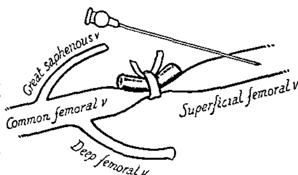


FIG 244—Diagram to show method of temporary occlusion of superficial femoral vein

Should the pressure remain below 30 centimetres with the superficial femoral vein temporarily occluded the vein should be ligated. The effect of temporary occlusion of the great saphenous vein in addition should be measured, if the pressure still remains below 30 centimetres it may be of benefit to ligate this vein as well (that is, both superficial femoral vein and great saphenous vein) The patient is allowed to get out of bed and to walk on the day following operation. The use of a *crêpe* bandage is advisable for 6 months after superficial femoral vein ligation. *Superficial femoral vein ligation*

(*c*) *Persistent superficial varices with deep veins returned to normal*

Once the normal condition of the deep veins and valves has been demonstrated, the treatment differs in no way from that of primary varicose veins.

(2) Complications of post-thrombotic varices

(*a*) *Oedema*

Oedema is often the most prominent symptom in the post-thrombotic syndrome, particularly when the deep valves are incompetent. The treatment remains as already described.

(b) Ulceration

The usual basic treatment already described is more than ever necessary, but operation is not to be undertaken until the ulcer is either healed or cleared of sepsis and is in a healing phase. The patient must be admitted to hospital and treated in bed, with local and, if necessary, systemic application of antiseptics appropriate to the sensitivity of the organism. As soon as the ulcer is healed operative treatment for the veins is undertaken; if it remains unhealed after two weeks of treatment despite sepsis being controlled, then a split-skin graft of the Thiersch variety should be applied to the ulcer at the same time as operation is performed upon the veins.

Skin grafting

Excision of ulcer

Large ulcers with extensive scar tissue in the base will require excision followed by skin grafting.

Sympathectomy

Lumbar ganglionectomy has been advocated for post-thrombotic ulceration on the grounds that the blood supply to the base of the ulcer will be improved and healing will be more rapid and more permanent and that grafts will take better. Unfortunately there is no clear experimental or empirical proof of this contention, for many other measures such as rest, antiseptics or grafts are usually used concomitantly with sympathectomy, so that a clear assessment of its efficacy is not available. It must be remembered also that lumbar ganglionectomy produces dilation of the veins in the leg by paralysing their vasomotor nerves.

(3) Pregnancy

Hormonal effects

It is well known that a patient may develop varicose veins for the first time during pregnancy or that persisting varices may become worse during the course of cyesis. This is now considered to be due chiefly to endocrine factors and to be associated with a general relaxation of smooth muscle. (*See* Pregnancy, Surgical Intervention during, Vol. 7, p. 127.)

Palliation

Spontaneous recovery or reduction in size of the varices usually follows delivery and so it is best to adopt palliative measures during pregnancy and to postpone definite treatment until two months after delivery, when the remaining varices can be dealt with in the usual way.

(4) Varices associated with arterial diseases

Arteriovenous fistula

The superficial veins often remain permanently dilated following operation for arteriovenous fistula. There are two factors to account for this. The first is that the veins have frequently undergone permanent damage to walls and valves from the high pressure of the arterial blood inside them while the fistula existed. The second is that after the fistula has been closed the superficial varices remain as true compensatory veins because the deep channels have been ligated and obliterated for some extent when the fistula was operated upon. In the second case any form of obliterative therapy for the varices is contra-indicated; if, however, the deep channels are intact it may be of benefit to undertake obliterative therapy, but only after careful investigation has shown that [illegible] channels are adequate and that the superficial ones are mere[illegible] and interfering with the efficient drainage of venous blood [illegible]

Diabetes mellitus and syphilis

Diabetes mellitus and [illegible] le factors in

cases of recalcitrant varices and ulceration of the legs, and examination of the urine, and serological investigations should be undertaken.

Buerger's disease Buerger's disease is a contra-indication to any form of obliterative venous injection. Quite small injections of sclerosing fluid may be followed by extensive and painful thrombophlebitis. When varices occur in the limbs of these patients they should be treated entirely by palliative measures.

Arterio-sclerosis Arteriosclerosis often accompanies varicose veins in older patients, and injection therapy may be performed, but with caution and always preceded by a small test dose. Some form of obliterative therapy is often useful also in the type of arteriosclerotic patient in whose limbs ischaemic symptoms preponderate; judicious obliteration of varices frequently improves the general efficiency of the circulation in the limbs and assists in the healing of ulcers.

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[References to other titles are given under Veins—Varicose, in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 12, p. 526.]

VISCEROPTOSIS

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1. INTRODUCTION

345.] Clinicians have long been familiar with a state of chronic invalidism characterized by exhaustion, both physical and mental, associated with vague digestive symptoms. In 1885 Glénard sought to explain this syndrome

Enteroptosis

on the physical basis of a prolapse of the intestines (enteroptosis) which, by causing angulation or kinking of the gut, leads to constipation and intestinal stasis with auto-intoxication, the accompanying pains being attributed to dragging on the sensitive peritoneal ligaments and membranes. The assumption by man of the erect posture, in the course of his evolution from the quadruped, was thought to provide an adequate explanation of this tendency because of the resulting unnatural strain on the visceral attachments. When

Nomenclature

all the abdominal viscera were involved the terms "visceroptosis" and "splanchnoptosis" were used; the suggestion that certain symptoms might be due to involvement of special groups of organs led to such terms as right-sided visceroptosis, left-sided visceroptosis and median visceroptosis; when the dominant discomforts were attributed to ptosis of a single organ its name was incorporated in the nomenclature, namely, gastroptosis, nephroptosis, hepatoptosis, caecoptosis, coloptosis and lienoptosis.

Later investigations, especially x-ray studies, have shown that visceroptosis as conceived by Glénard and his followers is a pathological myth, though if the original connotation suggested by its etymology be discarded the name may still be used to label the syndrome it formally sought to explain. There is precedent for this changed connotation in such words as artery and

melancholia. In this section the term visceroptosis applies solely to the clinical picture and not to any alleged pathology. A less committal name, the "chronic abdomen", coined by Hutchison (1925), has much to commend it; other authors emphasizing the psychogenic factors speak of the syndrome as an abdominal or visceral neurosis. The eponym, Glénard's syndrome, is rarely used in Great Britain. *"Chronic abdomen"*

2. CLINICAL PICTURE

The victim is usually a nulliparous woman between 20 and 40 years of age, but it must be emphasized that no age is immune and men are not infrequently affected. Commonly the history is one of having been a delicate child with a weak digestion and subject to frequent bilious attacks, regarded as acidosis or migraine. The only child, the spinster who sees the prospect of marriage receding because of such domestic ties as the care of an aged invalid mother, the housewife harassed by a large family and a small income, in brief, those subject to undue anxiety and worry form a large proportion of the sufferers. *History*

(1) Symptoms

Patients describe their symptoms in profuse detail with a liberal use of superlatives. Pains are "agonizing" or "unbearable"; flatulence is "terrific" or "appalling", minor worries are "heart-breaking" or "calamitous". They prompt their long recital from the *petit papier* on which they have jotted down their protean complaints.

The two major complaints are of fatigue, both physical and mental, and vague dyspepsia.

The weakness and exhaustion may be unrelated to exertion, though almost always worse after defaecation. There is an inability to concentrate, a failure of memory, headache, insomnia and depression. The abdominal discomforts are vague and variable, both in character and site. They include burning, raw, and dragging sensations often eased by lying down. Not infrequently there is right iliac discomfort which leads to a mistaken diagnosis of chronic appendicitis or appendix dyspepsia. Constipation is the rule but the abuse of aperients may lead to the patient complaining of diarrhoea with slime or "strings of mucus" and occasionally "intestinal membranes" in the faeces. These common features led to such labels as mucous or muco-membranous colitis, or mucous colic for the syndrome here discussed. Flatulence both by eructation and per rectum, poor appetite, and nausea with water brash, but rarely vomiting, also occur and there is often wasting, sometimes because the patient has starved herself in an attempt at relieving her abdominal discomforts, but not infrequently because starvation has resulted from the prohibitions of the many doctors consulted which have left her with few foods she believes she can assimilate. A history of dysmenorrhoea, irregular menses and leucorrhoea is rarely absent in women, and diurnal frequency of micturition is a common complaint, though nocturnal frequency is rare. *Fatigue* *Constipation* *Flatulence* *Dysmenorrhoea*

General symptoms include frequent colds and nasopharyngeal catarrh; cold, clammy and blue extremities with a tendency to Raynaud's syndrome. No part of the body is immune from pain, but backache, and the consequent diagnosis of lumbago or rheumatism, is very common and often associated *General symptoms*

with faulty posture. There is in some patients a tendency to faint on prolonged standing, thought to be due to over-filling of the splanchnic vessels, with resulting cerebral anaemia.

(2) Physical signs

Ptotic habitus

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Essential mobility of organs

be caused not only by mechanical forces but also by mental influences". Indeed it is clear that mobility is essential to the mechanism of visceral function and that fixation of an allegedly mobile organ is therefore wrong in essence. It is now nearly 30 years since these views were irrefutably sustained, yet they are still unappreciated by many who cling tenaciously to a physical visceroptosis as an explanation of the clinical picture here described. Two quotations from Alvarez (1946) embody tersely and vividly the present position. He declares, "It takes twenty years for a medical observation to get into the text-books but when once there no matter how obviously wrong it may be it takes a hundred years to die out"; and "I think I would as willingly ascribe [digestive] symptoms to a large navel, to a hooked nose, or to flaring ears, as to a mobile caecum or a redundant sigmoid flexure".

4. THE MECHANICAL CONSEQUENCES OF SEVERE PTOSIS

Although there can now be no justification for ascribing the symptoms of visceroptosis to be a falling of the abdominal viscera, there are three conditions in the causation of which the mechanical effects of severe ptosis may play a role. These are Dietl's crises, duodenal ileus, and torsion of the splenic pedicle.

(1) *Dietl's crises*

Aberrant renal artery

Neuro-muscular dysfunction

Dietl's crises are attacks of renal colic due, it is alleged, to nephroptosis kinking the pelvi-ureteric junction. Pyelectasis and hydronephrosis with their characteristic symptoms and signs may follow. It is doubtful if ptosis alone explains Dietl's crises; in some cases, an associated aberrant renal artery is found compressing the upper end of the ureter, thus causing firmer fixation and increased kinking when there is a tendency to nephroptosis; in others, there appears to be an associated neuromuscular dysfunction leading to achalasia at the pelvi-ureteric junction so that sympathectomy is certainly required, whatever be the indications for nephropexy, if the condition is to be relieved. It is of interest to note that biliary colic with obstructive jaundice has been attributed to nephroptosis, which in its descent drags the duodenum with it and thus kinks the common bile duct. Also, postural hypertension has been explained by the renal ischaemia produced by a kinked renal artery in nephroptosis.

(2) Duodenal ileus

Kellog (1913) and Wilkie (1921) were the main protagonists of so-called chronic duodenal ileus, in which vague obstructive symptoms are alleged to result from intermittent compression in the neighbourhood of the duodeno-jejunal flexure by the superior mesenteric vessels in such conditions as were earlier thought to lead to visceroptosis. Hurst (1927), however, regarded the condition as due to an anomalous fixation of the duodenum; normally this should drop with the stomach on standing, but, if it remains fixed, undue kinking of the duodeno-jejunal flexure results with gastro-duodenal stasis. With the outmoding of the concept of visceroptosis little emphasis is now placed on chronic duodenal ileus as a cause of abdominal discomforts.

(3) Torsion of the splenic pedicle

Torsion of the splenic pedicle with strangulation of the spleen is a rare but direct outcome of splenic hypermobility. The clinical picture is that of massive infarction of the spleen if the torsion leads to occlusion of the splenic artery. *Massive infarction of the spleen*

(4) Other considerations

This section on visceroptosis does not include considerations of prolapse of the uterus, vagina, and rectum. Their overt physical effects and their treatment by exercises, pessaries, and surgery are well established; though they may accompany the syndrome of visceroptosis, they play no direct part in its causation.

5. DIAGNOSIS

There are still some, though the number is diminishing, to whom the finding of a palpable kidney is an adequate explanation of any symptom of which a patient complains, and many are the records of disease, from vague dyspepsias to frank psychoses, which a supporting belt or a nephropexy is held to have cured. Most "cures" of this type result from a failure to distinguish between *post hoc* and *propter hoc*. To those who fall victim to this fallacy the whole range of disease lies within the scope of differential diagnosis in visceroptosis.

Although visceroptosis may mimic many organic dyspepsias and intestinal diseases, its diagnosis rests on the accompanying psychogenic, especially emotional, disturbances and the vagueness, variability, grotesqueness, fluctuation, long duration and purposefulness of the symptoms, in the absence of significant organic disease. It must not be forgotten that a patient with visceroptosis may have accompanying physical disease or may develop it during the long course of his disability, and that unequivocal signs of structural change, for example, haematemesis, a palpable tumour, or visible and palpable peristalsis with constipation, demand full investigation. In handling the nervous patient, however, intensive investigation is best avoided; it often raises doubts in the patient's mind of the physician's confidence in his own diagnosis. There is, however, increasing evidence that the nervous factors which produce the visceroptotic syndrome are similar to those which play a part in the genesis of peptic ulcer and of ulcerative colitis, so that too sharp a distinction between the psychological and the physical should not be drawn. *Accompanying physical disease* *Nervous factors*

6. DIFFERENTIAL DIAGNOSIS

Such diagnostic labels as caecum mobile, caecal stasis, and myxoneurosis intestinalis are merely descriptive of visceroptosis. To include them in the differential diagnosis is to fall victim to the tyranny of words. There are however, two labels which deserve fuller consideration, namely chronic appendicitis and constitutional inadequacy, the former because of the evils which have been wrought in its name, the latter because it offers a useful concept to those seeking to explain the clinical picture.

(1) Chronic appendi itis

The association of indefinite epigastric discomfort, nausea and flatulence with tenderness in the right iliac fossa, relieved temporarily by appendectomy,

Appendix dyspepsia

was held to justify a diagnosis of chronic appendicitis or appendix dyspepsia, even though unprejudiced pathological examination revealed no abnormality of the excised appendix. No more revealing comment on this operation is to be found than that of Alvarez (1946), who studied the results of appendectomy in 385 patients after operation. Amongst those who gave no history suggestive of an acute attack of appendicitis, less than 1 per cent were relieved of their symptoms for more than a few months, and 24 per cent were made worse; of those who were operated upon for an acute attack over 66 per cent were cured. Experience testifies abundantly to the clinical importance of confining both the diagnosis of chronic appendicitis and the consequent operation to those who have had recurring attacks of acute or subacute appendicitis, with symptomless latent intervals between the attacks.

(2) Constitutional inadequacy

No one has recognized more clearly than Alvarez (1946) the role of genetic biological inferiorities in the varied symptoms ascribed to visceroptosis. He calls for a prompt recognition of

> "the constitutional frailness or sickliness or psychopathy of these patients. We must see quickly that all their manifold troubles are due to the fact that their body and nervous system were built out of poor material, and that they can never be made over so that they will get well and stay well. We must stop looking hopefully for some one lesion to explain the marked disability, the painful fatigue, the psycho-neurosis, and the aches and pains everywhere; and when, during an examination, we run on to some variation from normal, we must not get excited about it but must realise that it could not account for a life time of assorted illness Finally, when we do recognise the functional nature of the syndrome, we must not rest satisfied with the diagnosis of chronic nervous exhaustion or neurasthenia as so many of us are now inclined to do, but must go on to apply a label—constitutional inadequacy—which will keep reminding us that we are dealing with an inborn and essentially ineradicable disease As I say to these patients, 'the only way in which I could hope really to cure you would be to start with another set of grandparents'."

Differing incidence

The differing incidence of this inadequacy in the various organs and systems explains the manifold clinical types. In some asthenia dominates the picture, in others pelvic symptoms, yet others show poor resistance to infection, neuro-circulatory asthenia, digestive troubles, or anxiety neuroses. It was earlier emphasized that this psychopathic make-up is not related to the physical build. It may be absent in the frail and present in the patient who looks physically well. It is because some patients are offended by the word "inferiority" that Alvarez prefers the term "constitutional inadequacy".

Heredity

He emphasizes its hereditary and familial incidence, and the frequent history in close relatives of frank psychopathic disorders, but he does not overlook the extrinsic factors which contribute to its overt clinical features. The term "constitutional inadequacy" may not reveal the deeper causes of the troubles for which it is held responsible, but it may well replace "visceroptosis" with its misleading implications of causation, and suggestion of local disease.

7. TREATMENT

Since no anatomical deformity underlies the abdominal discomforts of the patient with visceroptosis, there can be no place in treatment for sling or

fixation operations. Moreover, the relief which occasionally follows the wearing of an abdominal supporting belt is not due to a raising of dropped organs (indeed radiological examination shows that, in some patients who claim the greatest benefit from a belt, it actually presses the intestines down!) but to its preventing abdominal "bleeding" with consequent faintness on standing, and to its supporting a lax abdominal wall. A simple test for the possible value of abdominal support may be carried out by standing behind the patient and embracing the abdominal wall with both hands, thus exerting upward and backward pressure; if sudden relaxation of this pressure gives a dragging discomfort in the abdomen with giddiness, a supporting belt is worth a trial. *Fixation operations contra-indicated*

Eradication of the inherited constitutional diathesis is a problem in eugenics and not therapeutics. The shielding of the susceptible child from over-anxious parents is of prime importance, and in later years the removal of precipitating factors, both physical and psychological, demands the most careful enquiry into possible domestic, personal (including sexual), social, occupational and environmental factors. The advice given will depend on what information is elicited; fears must be unmasked and anxieties assuaged; and appropriate physical measures must be instituted where these are indicated. *Sociological factors*

The suitability of work will be judged by its nature and appeal, and by the physical and mental strains which it imposes; holidays and the need for rest periods during the day must be considered in relation to all the circumstances. Where so many factors play a part in causation, treatment must not be stereotyped, but should be particularized in their relation to the patient's needs. Above all, advice must be practical and within the patient's competence. The wife of a bank clerk, or the mother of three young children cannot winter in the south of France! The doctor, in handling his patient, must not add to her anxieties or fears. Axel Munthe confessed in *The Story of San Michele* that of his patients, "Many were not ill at all, and might never have been so had they not consulted me"—a sad retrospective indictment of his clinical skill. *Rest*

A warning must also be entered against regarding focal sepsis as responsible for the asthenia and "toxic" symptoms of the patient with visceroptosis. Dental extractions, tonsillectomy, sinus operations, and even cholecystectomy recur in the history of these patients. After all these mutilations the patient is more complaining than before. Only when in visceroptosis there is unequivocal evidence of local disease, for example, a root abscess or an antral empyema which itself demands relief, should its local treatment be undertaken. Even then no significant change in the patient's general condition can be hopefully anticipated *Focal sepsis*

Symptomatic measures are an adjunct to these general principles, not a substitute for them. Poor muscular tone may be helped by massage and exercises designed to improve posture. Courses of sunlight give comfort, and may increase resistance to infection. Too strict a dietetic régime may lead to under-nutrition and its attendant evils; in general, dry meals followed in 1–2 hours by liquids, especially if there is fullness and splashing after meals, help. Alkalis may be prescribed for hyperacidity, and diastase preparations with limited root vegetables, such as potatoes, turnips, carrots, swedes, parsnips and radishes, may be given for carbohydrate dyspepsia when there *Symptomatic measures* *Diet*

are nocturnal borborygmi and large undigested starch granules in the faeces. Much flatulence is due to aerophagy which should be appropriately countered. Lost weight may be regained by a fattening diet and rest, as in a Weir Mitchell régime. Nutritional defects including anaemias must be corrected by appropriate foods, iron and vitamins. Belladonna, a mild sedative, and a non-roughage diet help the spastic colon and the associated constipation. Strong aperients and regular enemas must be avoided, and the patient's mind should be disabused of preconceived notions about the grave consequences of missing a daily bowel movement. When constipation is associated with dyschezia re-education is indicated.

Weir Mitchell régime

These and a host of other symptoms may demand treatment in individual cases, but it must never be forgotten that the successful management of the visceroptotic patient demands a knowledge of the "whole" patient and that treatment must be aimed at restoring physical and mental harmony. In no other condition is it more important to think not of a disease, but of a man or a woman.

8. PROGNOSIS

The early case

If the relative parts played in visceroptosis by constitutional inadequacy and such extrinsic factors as physical strain, anxiety and unhappiness be accurately assessed, prognosis is not difficult. The early case, if freed from the stresses which occasioned the illness, should recover and remain well, provided that these extrinsic strains do not recur and that the patient lives within her capacity for muscular and mental effort. Where the family history reveals serious mental instability, when symptoms have recurred for several years and are excited by relatively slight mental and physical strain, and where the extrinsic causes cannot be eradicated (there are legal impediments to the removal of a nagging wife or of the inconsiderate and erring husband!) the outlook is one of chronic and continuing illness with perhaps occasional periods of improvement. Symptoms will often disappear during pregnancy, not because the enlarging uterus supports the "ptosed" viscera, but because bearing a child will often resolve an emotional conflict. An unwanted child will aggravate the invalidism. Partial remissions may follow any new method of treatment, medical or surgical, and lure the doctor into false hopes of cure. But these treatments involve rest, invite sympathy (especially when major surgical procedures are carried out) and often remove the patient from the scene of the worries responsible for her breakdown. It is to these general measures and not to the special therapeutic device that the temporary benefit is to be credited. The expectation of life is not reduced in visceroptosis; its victims exemplify the Polish proverb "the infirm live longest". To the harassed doctor they certainly seem to!

Pregnancy

Expectation of life

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VISUAL FIELDS–PERIMETRY AND INTERPRETATION

By H. M. TRAQUAIR, F.R.S.Ed., M.D., F.R.C.S.Ed.
Consulting Ophthalmic Surgeon, Royal Infirmary, Edinburgh

"*. . . there can be little doubt that in the thorough examination of the relative as well as absolute functional activity of all parts of the retina we possess a means of immense value in the localisation of intracranial disease. But it is not merely as a method of diagnosis that this examination deserves attention, in many cases it affords the most delicate means of ascertaining the course taken by any disease, especially when of intracranial origin*" (Berry, "Subjective Symptoms in Eye Diseases", Edinburgh, 1886.)

1. FUNCTION

346.] The function of perimetry in relation to intracranial disease is the correlation of defects in the field of vision with the site and nature of the causal lesion in the visual path.

2. THE VISUAL FIELD

(1) Extent

The maximal extent of the absolute field of vision of each eye separately is about 100 degrees temporally, 70 degrees downwards, 60 degrees nasally, and 65 degrees upwards. In practice the brow and nose limit the extent nasally and above, so that the relative field is restricted in these directions by the facial configuration. This must be remembered when measuring the peripheral boundary of the field. The field of the two eyes together, or binocular field, extends to about 200 degrees horizontally. As the field extends farther temporally than nasally the extreme temporal 30 or 40 degrees of the binocular field on each side, the temporal crescent, has only uniocular vision while the central 120 degrees has binocular vision.

(2) Visual acuteness of field

The centre point of the field, to which the gaze is directed, is the fixation point; the surrounding 25 or 30 degrees constitute the central field and the remainder is the peripheral field. The acuteness of vision is high at and near the fixation point; it falls towards the periphery rapidly on the nasal side, and less rapidly on the temporal side, so that very large test-objects are required to ascertain the peripheral maximal limits and very small objects to test the integrity of the central part. The field of vision may, therefore, be regarded as a hill with a high central peak and a surface sloping more steeply on one side than on the other. By testing the function of the field with serial objects of different sizes the surface may be surveyed in the same way as a hill is mapped by contour lines. These lines are termed isopters and are indicated by using the diameter of the test-object (O) as the numerator of a fraction (O/D) of which the denominator (D) is the distance at which the examination is conducted The isopter for 5/330, obtained by using a 5-millimetre object with a perimeter of 330-millimetre radius, gives almost the maximal peripheral boundary of the field, while the central field is similarly shown by the isopter for 1/2000 which gives a field extending to about 25 degrees from the fixation point (Fig. 245).

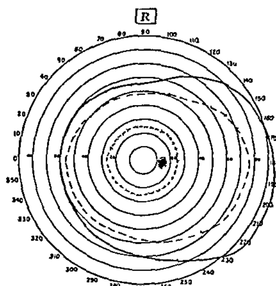


FIG 245.—The normal field showing isopters for 5/330, 1/330, and 1/2000 white (*By courtesy of Henry Kimpton.*)

Isopters

(3) Blind spot

The blind spot corresponds to the optic papilla. Its centre is about 15 degrees to the temporal side of the fixation point and slightly below the horizontal meridian. At 2 metres' distance it forms a vertical oval roughly about the size of the hand with fingers extended.

3. PERIMETRIC INSTRUMENTS

The instruments required are test-objects, a perimeter for the peripheral field, and a screen for the central field. Charts suitable for perimeter and screen are used for recording.

(1) Test-objects

The test-objects are the most important and much useful diagnostic work can be done with them alone. Suitable objects consist of circular paper discs mounted on short wire stems which fit into holders about a foot long for the perimeter and thirty inches long for the screen. The discs vary in diameter

Paper discs

from 1–70 millimetres or more (Fig. 246). It is sufficient to have a set 1, 2, 3, 5, 6, 10, 20, 40, and 70 millimetres in diameter, white on one side and red on the other. In default of the proper object and holder a wire or hat-pi armed with a piece of paper may serve as a makeshift.

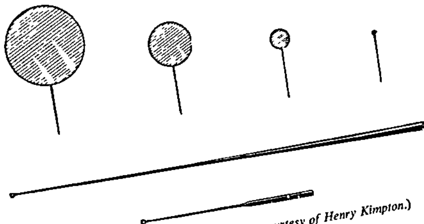


FIG 246 —Test-objects and holders (*By courtesy of Henry Kimpton.*)

(2) Perimeter

The perimeter should have an arc of 180 degrees and a radius of 330 millimetres. The simple non-mechanical, non-recording type is preferable.

(3) Screen

The screen should be 2 metres square and made of black material, such a cotton velvet, stretched on a light frame. A fixation point consisting of a gre or white disc a centimetre or less in diameter is attached in the centre b a black-headed pin. A larger fixation point may be used if the patient se badly.

Fixation point

A smaller screen may be used but it is less efficient.

4. METHODS OF EXAMINING THE FIELD

(1) Confrontation method

The confrontation method is probably the most generally useful to the surgeon A perimeter is not required. The patient should be placed with his back to the light. The eyes are examined separately and then both together (binocular field). The eye not under examination is carefully covered. The examiner faces the patient at about arm's length. The test-object in the short holder is introduced on the temporal side of the patient on the horizontal meridian about 2 feet from his eye and at right angles to the direction of his gaze. The patient should look steadily at the eyes of the examiner who is able to observe and correct any deviation of his vision. The object is then moved slowly towards the line of the patient's vision, keeping it the same distance from his eye, while asking him constantly whether he continues to see it or whether it disappears or becomes dim. In this way the horizontal and vertical

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and several oblique meridians are examined. If any defect is found, special attention is directed towards that part of the field and the examination may be followed by a perimeter test. Apparently blind areas may be further investigated by using a sheet of notepaper or the hand as the test-object. The hand may be opened or closed or the fingers may be moved to estimate the degree of perception present. Smaller white objects or coloured (red) objects may be used. In the latter case the recognition of the colour, not the visibility of the object, forms the criterion. In cases of suspected homonymous hemianopia the binocular field should be rapidly examined. The central field may be investigated, especially if the surgeon wears a black waistcoat, with a 1-millimetre object using a button as the fixation point.

Investigation of blind areas

Homonymous hemianopia

The confrontation test may be carried out on patients in bed, on those whose ability to co-operate is weak, and on infants and young children. A light or an attractive object may provoke response when introduced into one part of the field but not in another.

The test does not disclose minute details but is useful in connexion with the grosser defects such as homonymous hemianopia or central scotoma. It should not be regarded lightly but should be carried out with all the care and attention at the examiner's command.

(2) Examination with the perimeter

The perimeter is useful for the examination of peripheral vision if the confrontation test has proved negative or unsatisfactory, or if exact records are required. If artificial light is necessary a lamp near each side of the patient's head will suffice. The most useful test-objects are those of 3-millimetre and 1-millimetre size, and they are carried along the arc of the perimeter on a short holder. Unreliable responses can be checked by rapidly turning the edge of the object towards the patient or by hiding it behind the arc while continuing to ask him if he sees it. It is preferable, if an exact test is required, to use the screen for examination of the central field and the perimeter for the peripheral field.

Checking of unreliable responses

(3) Screen method

The patient is seated 2 metres (6½ feet) in front of the screen. The blind spot is rapidly mapped out with a 40-millimetre object and its position indicated by inserting black-headed pins at its margin. Then the central part of the field near the fixation point is carefully explored with objects of varying sizes according to the degree of vision present. Small objects down to 1 millimetre in size should be used before deciding that a defect is not present. The extent of the central field should be examined with 1-millimetre or 2-millimetre white objects which should give fields of about 25 and 30 degrees respectively in normal conditions Special attention should be paid to the oblique meridians in the search for early changes (Figs. 247 and 249) If defects are found larger objects should be used to estimate the degree of blindness.

Oblique meridians

In all perimetric examinations slight deviations from the normal maximal standards, especially if small objects are used, should be regarded with caution unless the shape of the field is also changed. It is always the shape rather than the size of the field which is important.

Deviations from maximal standards

It is essential to recognize that perimetry is not merely the delimitation of

the peripheral boundary of the field but includes the exploration of its whole surface. Defects which may not affect a peripheral isopter may be pronounced for an internal isopter (Fig. 247).

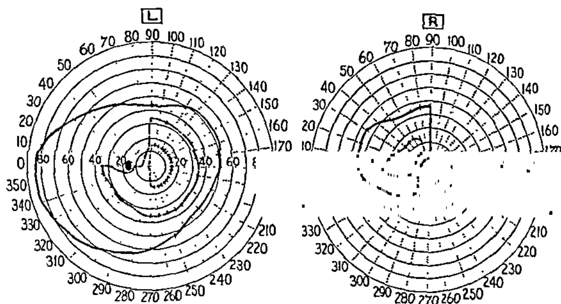


Fig. 247. [illegible]

5. INTERPRETATION

(1) Characters of field defects

The chief characters of field defects are position, size, shape, intensity, uniformity, onset and course. These characters reflect the site and nature of the causal interference in the visual path. Interpretation is both anatomical and pathological and, as the different parts of the path are more commonly affected by certain conditions than by others, the determination of the site of interference also provides indications as to its probable nature.

(2) Anatomy

The nerve fibres preserve their relative positions along the path so that at any part a ventral interference produces an upper field defect, and a right-sided lesion a left-sided defect, and so on (Fig. 248). On account of the partial decussation of the optic nerves at the chiasma the nasal or crossed fibres of one eye join the temporal or uncrossed fibres of the other and the two sets of fibres proceed together as the optic tract to the lateral geniculate body. Thence a new set of fibres, the optic radiation, passes to the visual cortex in the calcarine area of the occipital lobe. It is important to note that the exact apposition of each crossed fibre to its uncrossed mate is incomplete until the posterior part of the tract, or even the geniculate body, is reached. Thus a small lesion in the tract, especially in its anterior part, may affect more crossed than uncrossed fibres—or *vice versa*—and thus produce an asymmetrical or incongruous homonymous hemianopia in which one field is earlier or more severely affected than the other.

Optic radiation

Incongruous homonymous hemianopia

After leaving the lateral geniculate body the fibres pass backwards as the optic radiation to the visual area of the occipital cortex in which the temporal periphery of the field is represented most anteriorly in the lower lip only of

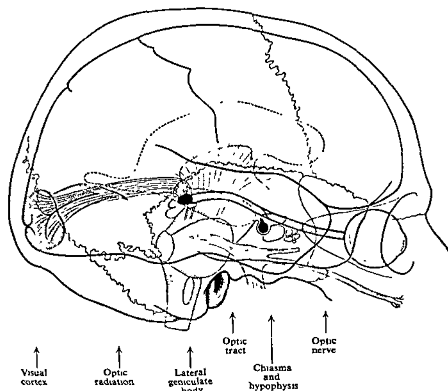


FIG 248—The visual path, showing its more important relationships. (*By courtesy of Henry Kimpton*)

the calcarine sulcus, the intermediate parts successively more posteriorly in the post-calcarine sulcus and the central area at the occipital pole. A lesion involving the visual area may include—or spare—the most anterior part alone thus introducing a suprageniculate form of incongruity affecting the temporal crescent only. With this exception the presence of incongruity in homonymous hemianopia indicates a subgeniculate site of interference. *Lesion of visual area*

According to another description (*see* Brain—Tumours and Technique, Vol. 2, p. 423) the most ventral fibres of the radiation, after leaving the lateral geniculate body, pass into the anterior part of the temporal lobe nearly as far forwards as the tip of the inferior horn of the lateral ventricle before turning backwards, to the lower part of the occipital visual cortex. Perimetric evidence, however, does not support this course.

The visual path may, therefore, be regarded as consisting of subgeniculate and suprageniculate parts The former includes subchiasmal, chiasmal, and suprachiasmal portions. With the exception referred to, all suprageniculate field changes are homonymous and congruous. Changes of subgeniculate origin are incongruous *Visual path*

The intracranial part of the optic nerve lies below the frontal lobe with the *Intracranial part of optic nerve*

carotid artery on its lateral side as it joins the chiasma. It is here subject to interference by frontal lobe tumours and abscesses, meningiomas, hypophysial tumours and aneurysms. The chiasma and tracts are specially vulnerable to hypophysial tumours, meningiomas and aneurysms. Behind the geniculate body vascular affections are common and more posteriorly tumours again play an important part.

Foster Kennedy syndrome

A frontal lobe tumour or a meningioma affecting the optic nerve may produce the Foster Kennedy syndrome of central scotoma with primary optic

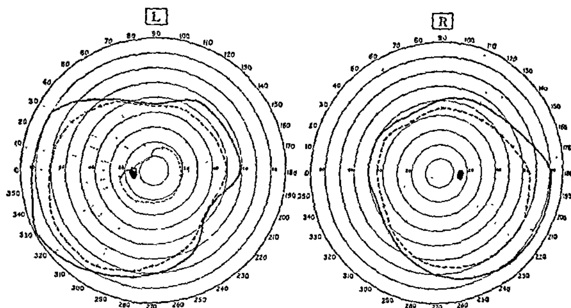


FIG 249.—*Bitemporal hemianopia, incipient stage. Objects 5/330, 1/330, 1/2000 Characteristic change in central area of one field only.* (*By courtesy of Henry Kimpton.*)

atrophy on the side of the lesion and papilloedema on the other side. Hypophysial tumours, meningiomas, or other swellings between the nerves produce field defects corresponding to the incidence of the interference with the nerve fibres concerned. As the interference is in the first place from below and affects the crossed fibres, the usual initial field change is a depression in the upper temporal quadrant of one field shown by a local indentation of the isopter for 1/2000 (Fig. 249) This is followed by more pronounced depression of the quadrant and extension of the defect into the lower temporal quadrant.

Bitemporal hemianopia

Similar changes proceed in the field of the other eye and bitemporal hemianopia is produced, progressing unequally in the two fields, clockwise in the right field and counter-clockwise in the left, until the last remains of vision are confined to one or both upper nasal quadrants (Figs. 250 and 251). This sequence, which is pathognomonic of chiasmal interference, can usually be easily demonstrated by the use of several test-objects of different sizes.

Unilateral blindness

Bitemporal central scotomas

Blindness of one eye with retention of the nasal field, or of its upper quadrant only, is strongly significant of a tumour beneath the anterior part of the chiasma. Prominence of bitemporal central scotomas, on the other hand, indicates a more posterior incidence of the interference as the macular fibres cross in the back of the chiasma. Very slowly developing growths may *deform the pathway to quite a considerable extent without producing*

pronounced field changes in contra-distinction to those effected by rapidly growing lesions.

Temporal lobe tum

Interference on the temporal side of the tract produces incongruous homonymous hemianopia (Figs. 252 and 253), appearing earlier and being more severe in the nasal side of the field of the homolateral eye. In the case of temporal lobe tumours, for example, if the lesion is low the upper nasal field quadrant is affected first, and if high, the lower nasal quadrant. Interference on the medial side of the tract, as in the case of hypophysial tumours extending backwards, also causes incongruous homonymous hemianopia, but this commences on the temporal side of the field of the eye opposite to the first affected tract. Sometimes a bitemporal hemianopia may become homonymous as the incidence of the interference shifts (Fig 252).

Hypophy tumours

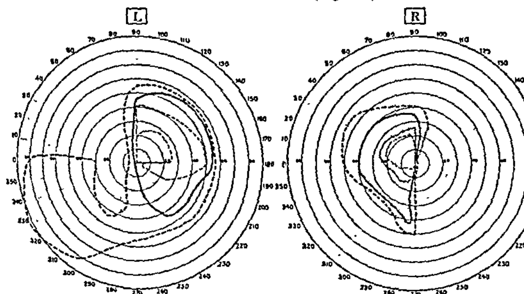


FIG 250.—Bitemporal hemianopia, advanced stage. Temporal field still partly present on left side for a very large object. The use of small objects shows that both fields will ultimately terminate in the upper nasal quadrants (*By courtesy of Henry Kimpton.*)

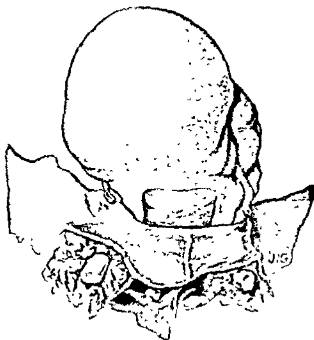
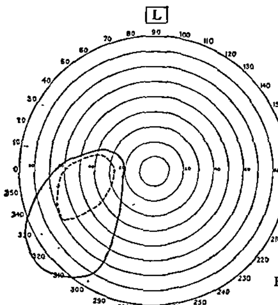


FIG 251.—Tumour which caused the fields shown in Fig. 250 (Natural size) (*By courtesy of Henry Kimpton.*)



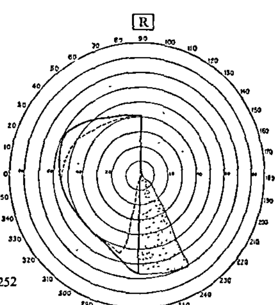


Fig 252

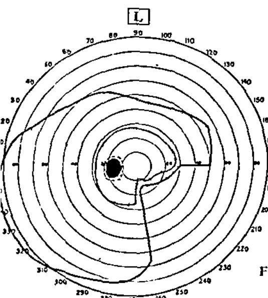


Fig 253

FIG. 252.—Homonymous incongruous hemianopia from tract involvement. The dotted area indicates an area of weak vision. Note incongruity indicating subgeniculate interference. (*By courtesy of Henry Kimpton*)

FIG. 253.—Anterior view of hypophysial tumour which first caused bitemporal hemianopia and then the right homonymous incongruous hemianopia shown in Fig 252, evidently due to involvement of the left optic tract. (*By courtesy of Henry Kimpton*)

FIG 254.—Right lower quadrant congruous homonymous hemianopia due to meningioma involving posterior temporal and lower parietal areas of left side compressing optic radiation. Subsequently the right upper quadrants became affected causing complete right hemianopia. A year after operation for removal of tumour, the fields were reported normal. (*By courtesy of Henry Kimpton*)



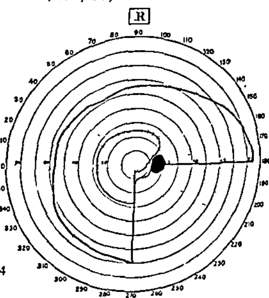


Fig 254

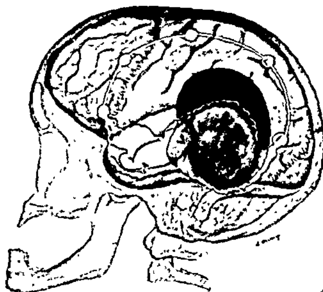


Fig. 255.—Drawings of tumour causing field change shown in Fig. 256. (*By courtesy of Henry Kimpton.*)



Fig. 256.—Homonymous hemianopia with temporal crescent or "half moon". Tumour involving the fibres of the optic radiation The presence of the half moon shows that the interference with the visual path did not extend as far forwards as to interfere with the fibres from the anterior end of the calcarine sulcus (*By courtesy of Henry Kimpton*)

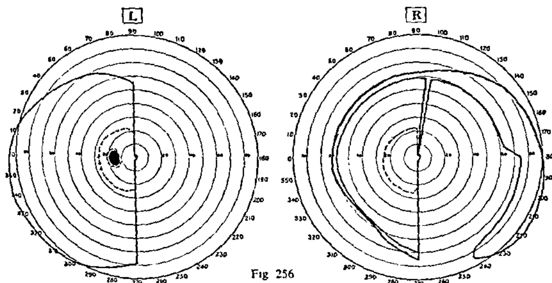
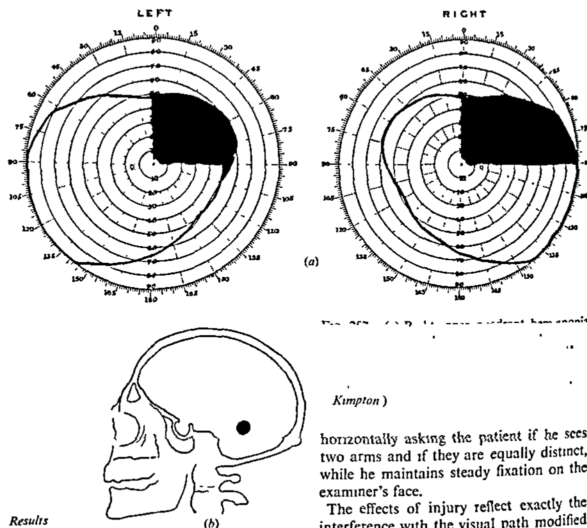


Fig 256

Suprageniculate hemianopias

Suprageniculate hemianopias, with the exception already mentioned, are always congruous, equal in size, shape, intensity, and onset on the two sides (Figs. 254 and 255). In tumour cases, in which the hemianopia may be almost the only symptom, the onset may be so insidious and gradual that it may be unnoticed by the patient and easily missed by the examiner unless the fields are examined by weak stimuli such as a 1-millimetre object at 2 metres distance (Fig 256). Modifications of the confrontation method are useful; the examiner may stand several yards from the patient and hold out both arms

Modifications of confrontation method



Kimpton)

horizontally asking the patient if he sees two arms and if they are equally distinct, while he maintains steady fixation on the examiner's face.

Results

The effects of injury reflect exactly the interference with the visual path modified by the course of the lesion (Fig. 257).

The results of perimetric examination should be fitted into the clinical picture to form part, but not the whole, of the basis of diagnosis. They are also useful in helping to estimate the progress of a morbid process and the effects of treatment.

[References to other titles are given under Visual Fields in the Index Volume.]

VITAMINS AND NUTRITION IN RELATION TO SURGERY

By J. R. MARRACK, M.D.

Professor of Chemical Pathology, University of London

1. VITAMIN A

(1) Deficiency

347.] Deficiency of vitamin A has two distinct effects. In the first place, vitamin A is a constituent of visual purple, on which vision in a dim light depends. When the supply of vitamin A in the body is depleted the regeneration of visual purple after exposure to a bright light is slow and dark-adaptation is impaired. This impairment is the basis of a test for deficiency of vitamin A. *Impairment of dark-adaptation*

In the second place, vitamin A seems to be essential for the maintenance of the normal structure of certain epithelial cells. When the supply of vitamin A is too low these cells undergo keratinizing metaplasia. This metaplasia occurs in rats in various situations. Squamous epithelium replaces the ciliated epithelium of the bronchioles; foreign materials are not eliminated and the rats are liable to broncho-pneumonia. Vitamin A was, for a time, called the anti-infective vitamin. In human beings severe deficiency of vitamin A can lead to the change of the epithelium of the cornea called xerophthalmia; but it is uncertain how far keratinizing metaplasia, when found in the air passages, is due to the lack of vitamin A. Failure to absorb vitamin A can be demonstrated in sprue, coeliac disease and in cystic fibrosis of the pancreas. After very large doses of the order of 10,000 i.u per kilogram of body-weight, the concentration in the plasma of normal persons rises by about 100 i.u. per 100 millilitres, in the plasma of patients with these diseases it does not rise by more than 30 i.u. The liability to infections of the respiratory tract in children who have congenital cystic fibrosis of the pancreas is attributed to metaplasia in the bronchial tract resulting from this failure to absorb vitamin A. *Keratinizing metaplasia* *Xerophthalmia*

Experimental deficiency

In the experiment made by the Accessory Food Factors Committee of the Medical Research Council (1945) the subjects lived for periods of up to 2 years on diets which supplied practically no vitamin A or carotene, which is a precursor of vitamin A. They were not abnormally liable to infections of the respiratory tract. It is possible that keratinizing metaplasia in human beings occurs only with extreme and prolonged deficiency. In Great Britain the present rations of butter and margarine supply some 500 i.u. of vitamin A per day. This is about one-sixth of the 3,000 i.u. which are commonly accepted as the amount needed by an adult. Some degree of impairment of dark-adaptation may be common (Yudkin, Robertson and Yudkin, 1943), but this basic allowance, which practically everyone receives, is probably ample to prevent the keratinizing metaplasia. Supplements of vitamin A have had little or no effect on the incidence or severity of respiratory infections (Bransby and his colleagues, 1946).

(2) Hypervitaminosis

Spontaneous fractures

Haemorrhage

Rats which are given excessive doses of crystalline vitamin A suffer from a peculiar condition of which the most striking features are rarefaction of the bones with spontaneous fractures, and reduction of the concentration of prothrombin in the plasma with consequent liability to haemorrhage. Other effects are roughening of the skin, loss of hair and retarded growth.

If rats are given vitamin K in doses of 25 micrograms per day with these large doses of vitamin A, the prothrombin in their plasma does not fall, though they still develop rarefaction of the bones (Light, Alscher and Frey, 1944; Walker, Eylenburgh and Moore, 1947).

Bear liver contains exceptionally large amounts of vitamin A, of the order of 400,000 i.u. per ounce (Rodahl and Moore, 1943). Both men and dogs get a severe illness after eating bear liver; the most striking feature of the illness is peeling of the skin, particularly on the face. Half a pound of liver, which contained 400,000 i.u. per ounce, would supply about 3,200,000 i.u. The minimum doses that produce these effects in rats are very large; 15,000 i.u. is about 5 milligrams and would be enough to keep a rat in health for 5,000 days. The amount in 8 ounces of bear liver would be enough for a man for 1,000 days. It is possible that preparations of crystalline vitamin A are contaminated with small amounts of a more toxic substance. Hypervitaminosis A is most unlikely to occur under ordinary conditions because ox liver contains only about 4,000 i.u. per ounce and halibut-liver oil 50,000 i.u. per ounce.

(3) Assessment of vitamin A

Follicular keratosis

Many estimations of vitamin A in plasma are untrustworthy; the concentration is affected by factors other than the amount absorbed from the food (Marrack, 1948). The estimation, therefore, cannot be regarded as a satisfactory way of assessing the state of nutrition with respect to vitamin A. The dark-adaptation is a satisfactory index if correct methods are used (Yudkin, Robertson and Yudkin, 1943), but the test is not convenient in practice. It is doubtful whether the follicular keratosis, which was considered to be a sign of deficiency of vitamin A, is related to vitamin A (Stannus, 1945); it was not found in the subjects deprived of vitamin A and did appear in those deprived of ascorbic acid (Accessory Food Factors Committee, 1945, 1948).

2. VITAMIN B

In earlier studies deficiency of vitamin B was found to lead to distension of the intestines. In these studies vitamin B_1 was not distinguished from others of the B group. Wintrobe and his colleagues (1941) have found that abdominal distension is one of the early signs of deficiencies of vitamin B in pigs. Leithausen (1948) has described 6 patients with great intestinal distension which was apparently attributable to nutritional deficiency and which, in 4 cases, disappeared when large doses of vitamin B_1, together with a preparation of B complex, were given. *Intestinal distension*

There is evidence that the need for various vitamins is increased by hyperthyroidism. Attempts have been made to maintain a normal rate of growth in young animals fed with thyroid by giving large doses of the known vitamins. If whole liver or brewers' yeast is also given, the rate of growth of young rats and the rate of development of the ovaries approach normal levels in spite of feeding with thyroid (Ershoff, 1947; Betheil, Wiebelhaus and Lardy, 1947); the basal metabolic rate, however, is not reduced by these supplements It seems, therefore, that liver and yeast contain an unknown factor of the B group that counteracts some of the harmful effects of hyperthyroidism. This is a further argument for the use of the B group of vitamins as the natural complexes rather than as isolated vitamins. *Hyperthyroidism*

3. VITAMIN C

The relationship of vitamin C to healing is dealt with in another chapter (*see* Scurvy; Vol. 7, p. 510). After infliction of a wound the concentration of ascorbic acid in the plasma and in many organs falls, and ascorbic acid accumulates in the tissues surrounding the wound. Lund and his colleagues (1947) have found low concentrations of ascorbic acid in plasma and low excretions of ascorbic acid, vitamin B, riboflavine and nicotinic acid in the urine of patients with severe burns, in spite of a generous intake. After a severe burn ascorbic acid might not be found in the plasma, even though amounts of ascorbic acid had been given which would raise to high levels the concentration in the plasma of a subject with frank scurvy. Low concentrations of ascorbic acid in plasma and low excretions have been found in infections. It seems that the requirements of ascorbic acid and of other vitamins may be increased in various surgical conditions.

(1) Deficiency

The experiment conducted by the Accessory Food Factors Committee of the Medical Research Council (1948) indicates that 10 milligrams of ascorbic acid per day is enough to ensure satisfactory healing of minor wounds inflicted on healthy persons. In Great Britain potatoes are the staple source of ascorbic acid in the diet at present; during the first half of the year, before new potatoes come on the market, a moderate helping of potatoes may provide no more than 4 milligrams of ascorbic acid Green vegetables are scarce and expensive during the first 3 or 4 months of the year. Five diets for a week in 3 hospitals in the Greater London area (King Edward's Hospital Fund for London, 1943) provided averages of 3, 3, 6, 13 and 10 milligrams per day. People who eat relatively little fruit and vegetables even

when they can get them may not accumulate enough ascorbic acid to tide them over the lean months at the beginning of the year. Those who live on restricted diets, owing to poverty, fads, excessive consumption of spirits or as a method of treatment of some disease, are still more likely to go short of ascorbic acid. Deficiency severe enough to impair the healing of wounds is not improbable even though human needs are so low. Prunty and Vass (1944) found that a considerable number of hospital in-patients had under 0·2 milligram of ascorbic acid in 100 millilitres of plasma.

Relation of ascorbic acid concentration to healing

The experiment of the Accessory Food Factors Committee (1948) and Bartlett's clinical observations (Bartlett, Jones and Ryan, 1942) suggest that if the concentration of ascorbic acid in the plasma is over 0·2 milligram per 100 millilitres, healing should be satisfactory.

Estimations of the higher levels of ascorbic acid in plasma agree fairly well; thus most observers agree that after a prolonged period in which the average daily intake of ascorbic acid is about 0·7 milligram per kilogram of body-weight, the concentration in the plasma is about 0·5 milligram per 100 millilitres. But when the intakes and concentrations in the plasma are lower, observers disagree. Thus after long periods on 20 milligrams per day (about 0·3 milligram per kilogram), Pijoan and Lozner (1944) and the Accessory Food Factors Committee (1948) find under 0·1 milligram of ascorbic acid in 100 millilitres of plasma; while Lowry, Bessey and Lopez (1946) find 0·2 milligram. When the concentration found is 0·3 milligram or more the subject is most unlikely to be so deficient in ascorbic acid that healing is impaired; but it is not advisable to base conclusions on lower concentrations.

Leucocyte-platelet layer

The discrepancies between estimates of ascorbic acid in the leucocyte-platelet layer are more surprising. Thus most observers (Pijoan and Lozner, 1944; Lowry, Bessey and Lopez, 1946; Wolfer and his colleagues, 1947) agree in finding over 20 milligrams per 100 millilitres when the intake is about 70 milligrams per day. But the Accessory Food Factors Committee found a concentration of only 10 milligrams when the intake was at this level. The Oxford Nutrition Survey (Adcock and Fitzgerald, 1945), consider that the concentration is low when it falls below 14·5 milligrams per 100 millilitres, and very low when under 10 milligrams.

(2) Assessment of vitamin C

Saturation test

The most satisfactory test to use when low concentrations are found in the plasma or when deficiency is suspected for other reasons is a saturation test according to the method of Harris and Abbasy (1937). The dose of ascorbic acid is 50 milligrams per 10 pounds of body-weight (11 milligrams per kilogram), reckoned to the nearest 50 milligrams. Ascorbic acid is estimated in the urine passed between 3½ hours and 5½ hours after the dose is given. If the ascorbic acid in this urine is 5 milligrams or more per 14 pounds of body-weight (0·8 milligrams per kilogram) the subject is said to be "saturated" and the test is ended. If the amount is less the test is repeated day by day until the subject is saturated. If the initial concentration in the plasma was 0·3 milligram or more per 100 millilitres the subject should be saturated in 3 days or less (Prunty and Vass, 1943). Judging by the experience of Bartlett, Jones and Ryan (1942) an intake of only 100 milligrams a day after admission to

hospital is not enough to ensure good healing if the initial concentration was under 0 2 milligram per 100 millilitres. This test has the advantage that the patient is saturated as the test is carried out.

The capillary fragility measured by the number of ecchymoses produced by pressure has no relation to the supply of ascorbic acid.

4. PROTEIN

It is probable that 10 out of the 23 amino acids in the body are indispensable, that is, human beings cannot synthesize them from other amino acids. Thus the dispensable amino acids, tyrosine and cystine, can be made from phenylalanine and methionine; but the indispensable amino acids, phenylalanine and methionine, cannot be made from tyrosine and cystine. The dispensable amino acids in the proteins of food are not superfluous; if tyrosine is not provided in the food the supply of phenylalanine must be depleted in order to make it.

Methionine

Methionine holds a special position. It has an available CH_3 group and, like other compounds with such a group, it protects the liver from fatty infiltration, which in time leads to generalized fibrosis. It also contains sulphur and, in common with the other sulphur-containing amino acid, cystine, it protects the liver against various toxic substances which may cause necrosis. Methionine also seems to have some special function in connexion with healing, for Localio, Morgan and Hinton (1948) found that subcutaneous injections of methionine hastened the healing of wounds in rats which had been fed on a low protein diet. However, administration of methionine does not lead to a reduction of the loss of nitrogen by human beings or by dogs suffering from burns (Meyer, Hirschfield and Abbott, 1947), such as Croft and Peters (1945) found in burned rats.

(1) Deficiency

Tensile strength of wounds

When animals are depleted of protein, healing is delayed and the tensile strength of wounds is less than it is in normally fed animals (Kobak and his colleagues, 1947). The concentration of protein in the serum of such animals is low, but the tensile strength of wounds is not related to the level of serum protein Depletion of protein also delays the formation of callus after injuries to bones (Rhoads and Kasinkas, 1942).

Loss of nitrogen balance

After injuries and during infections the rate of breakdown of body protein exceeds the rate of synthesis. The consequent negative nitrogen balance is found even after relatively minor injury, such as an operation for repair of a hernia. The maximum loss usually occurs towards the end of the first week; at the same time the concentration of albumin in the serum falls, the globulin rises and the metabolic rate is increased. After more severe injuries the loss may be equivalent to the protein in 8 pounds of muscle (Cuthbertson, 1932).

Starvation and chronic disease

During the acute phase of the breakdown of body protein little can be done to check this loss; if extra protein is given the loss of nitrogen rises to almost the same extent. Nor can well-nourished people build up much reserve protein beforehand, to meet the loss People whose stock of protein has been depleted by starvation or by chronic disease can ill afford to lose this extra protein and are liable to heal badly. They should be well fed, if possible,

before operation, *though it is doubtful whether the* large amounts of protein given by Koop and his colleagues (1946) are advisable.

Replacement of lost protein

The protein lost *must be made up during* convalescence and the nature of the amino acids in the food may limit the rate of repair. Cereal proteins contain only about one-seventh *of the lysine in muscle proteins;* about 120 pounds of flour are needed to supply the lysine in 8 pounds of muscle. The food should also *provide ample calories to make up for losses; there is no* need for more than 12–14 per cent of the calories of the diet to be derived from protein.

(2) Hydrolysed proteins

Opinions differ widely about the value of hydrolysed proteins (Cuthbertson, 1948, 1949; Elman, 1949). Their value *may depend on the degree to which* the proteins have been broken down. Proteins are split up into their constituent amino acids in the intestines; these amino acids are absorbed and it is probable that the amounts of peptides absorbed are small. In the preparations of digested proteins, called by the odd name of protein "hydrolysates" (it should be hydrolytes), which are used for intravenous injection, about one-

Polypeptides

third of the nitrogen is in the form of polypeptides; these contain, on an average, 3–4 amino acid residues per molecule (Cox and Mueller, 1946). Injection of these preparations is followed by a rise of the concentration of peptides in the plasma to relatively high levels, whereas after proteins are eaten the concentration falls (Christensen and his colleagues, 1947); $\frac{1}{3}$–$\frac{1}{2}$ of the injected polypeptide is excreted in the urine of dogs and men (Christensen, Lynch and Powers, 1946; Marshall, 1946, personal communication). Re-

Reactions

actions may be mainly due to these polypeptides, although pure amino acids may cause nausea and vomiting if injected rapidly (Werner, 1947). The severity of reactions after injection of hydrolysed proteins is not proportional to the concentration of amino acids in the plasma (Hecht, 1946).

(3) Assessment of protein

The lowest reported *limit of the concentration of protein in the serum of* healthy persons is under 6 grammes per 100 millilitres, but it is probable that *if correct methods of estimation are used the lower limit is considerably*

Concentration limits

higher than this. The concentration falls by about 0·6 gramme per 100 *millilitres during rest in bed and rises after getting up* (Perera and Berliner, 1943). It may be assumed that a concentration of under 6 grammes per 100 millilitres in patients confined to bed is abnormally low, but when the concentration in a patient's serum is above this level it cannot be inferred that he has not lost considerable amounts of protein. Concentrations of 7 grammes or more per 100 millilitres have been frequently found in the serum of persons suffering from famine oedema.

Discrepancies in estimation

Various methods of estimating serum proteins give discrepant results. Thus, if the factor 360 proposed by Phillips and his colleagues (1945) when calculating serum proteins *from the specific gravity found by the copper sulphate* method is accepted, the results will be about 7 per cent lower than those which *would be found by the Kjeldahl method with precautions to ensure complete* incineration, for example, 7·0 grammes instead of 7·47 grammes per 100 *millilitres; the correct factor is* 384 (Hoch and Marrack, 1945).

5. VITAMINS A, C, D AND K

For information concerning other vitamins in relation to surgery, the reader is directed to the following.

Vitamin D: *see* Bones, Vol 2, p. 294, and Lupus Vulgaris, Vol 5, p 480.
Vitamin K: *see* Jaundice, Vol. 5, p 181.
Vitamins A, C, D and K: *see* Gall-bladder and Bile Passages, Vol. 4, p. 254

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[References to other titles are given under Vitamins and Nutrition in Relation to Surgery, in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 12, p. 570]

VITREOUS—INJURIES AND DISEASES

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1. DEFINITION

348.] In its normal state the vitreous body is an inert, jelly-like structure formed as a cell-product and subserving optical functions. It has the properties of a hydrophilic gel in unstable equilibrium. In post-natal life it possesses no blood-vessels and so cannot become inflamed; pathological reactions are therefore solely degenerative and involve changes such as liquefaction, opacification, shrinkage and detachment.

2. SPECIAL AIDS TO DIAGNOSIS

For studying these degenerative changes the slit-lamp is essential as by ophthalmoscopy the vitreous appears quite transparent, the only visible alteration being the presence of opacities dense enough to obstruct transmitted light. For examination of the posterior vitreous the slit-lamp requires a deviation prism (Goldmann), which swings on an arm in front of the illuminating lens and which reduces the beam-microscope angle to 5 degrees, and a contact lens is desirable. *Slit-lamp* *Goldmann prism and contact lens*

3. INJURIES—GENERAL CONSIDERATIONS

It is of fundamental importance in considering the treatment of penetrating wounds of the eye associated with vitreous prolapse to bear in mind (1) that

the vitreous gel is never renewed but is merely replaced by intra-ocular fluid, and (2) that the vitreous body forms an excellent culture medium for bacteria so that any infective process reaching it tends to develop in intensity rapidly.

4. PROLAPSE OF THE VITREOUS BODY

(1) External

Surgical principles

Conjunctival flaps

Prolapse of the vitreous body may be external or internal. Penetrating wounds of the sclera posterior to the lens diaphragm are more likely to be complicated by an external prolapse of the vitreous than are those occurring anteriorly. The principles of surgical treatment in such cases are to cleanse the wound; to remove dirt and foreign matter; to abscise prolapsed vitreous and other intra-ocular tissue which has become contaminated by exposure in the conjunctival sac; to replace structures adjacent to the wound into their normal anatomical position, and to effect closure of the wound by suture or by covering it with a conjunctival flap or both. Conjunctival flaps in these cases should be so designed that they are clear of the scleral wound so that the danger of direct infection from the conjunctival sac is minimized.

(2) Internal

Causes

Secondary glaucoma

Eserine

Cyclodialysis

An internal prolapse or vitreous hernia wherein the gel comes forward into the anterior chamber is seen after intracapsular cataract extraction, after a capsulotomy following discission of the lens or an extracapsular cataract extraction, and in cases of dislocation or subluxation of the lens. As a rule, a hernia of the vitreous does not give rise to symptoms but occasionally pseudo-membranes form on the inter-face between aqueous and vitreous with consequent visual impairment, and occasionally a secondary glaucoma develops. Such a rise of tension, occurring particularly after a capsulotomy, may be due to a post-operative iridocyclitis, to obstruction of the angle of the anterior chamber by the vitreous gel itself—a type often dramatically relieved by local application of eserine and heat—and thirdly to obstruction of the pupil by the hernia with consequent iris bombé and the development of peripheral anterior iritic synechiae, a type which is probably best dealt with by the operation of cyclodialysis.

5. FOREIGN BODIES IN THE VITREOUS

Removal by anterior route

Removal by posterior route

In civil life a foreign body in the vitreous is usually a small particle of iron or steel and is therefore magnetic. If less than 3 millimetres in its longest dimension such a foreign body is best extracted by the anterior route, the principle of which is to bring the foreign body forward into the anterior chamber by the giant magnet and from thence to remove it by means of a hand magnet through a keratome section.

If the foreign body is large, ragged-edged or only lowly magnetic, as so often occurred in war injuries, it is best extracted by the posterior route through an incision in the sclera made as near to the foreign body as possible, hence the importance of accurate pre-operative radiological localization of the foreign body before employing this method of approach.

6. PUS IN THE VITREOUS

Infection of the vitreous is almost invariably due to a perforating wound or ulcer. Cases of metastatic inflammation of the retina and choroid also occur and lead to a similar result, though in these cases (metastatic endophthalmitis) the inflammatory process is usually less severe than when the organisms gain access to the eye exogenously. Penicillin should always be given in such cases and as adequate therapeutic levels in the vitreous can now be obtained by subconjunctival injection this method should be employed rather than direct intra-vitreal injection, which is not without toxic effects on the retina (Duguid and his colleagues, 1947; Gardiner and his associates, 1948). The dose suggested by Sorsby is 500,000 units of crystalline penicillin in 0·5 millilitre of adrenaline solution, 1:1,000, given subconjunctivally at 24-hour intervals (Sorsby and Ungar, 1948). If the intra-ocular infection is not controlled by this means and a frank panophthalmitis develops, as shown by intense inflammation of the whole eye and a yellow mass behind the lens, the globe should be eviscerated by excising the cornea and scooping out all the intra-ocular contents, special care being taken to leave no uveal tissue behind. Excision of the eye is undesirable as in this operation the optic nerve is cut across, the intervaginal space opened and hence a potential pathway for virulent organisms to gain access to the meninges is laid bare.

Causes

Subconjunctival penicillin

Dosage

Panophthalmitis

Evisceration of globe, not excision

Meningitis

7. BLOOD IN THE VITREOUS

Haemorrhage into the vitreous is a frequent complication of contusion injuries and perforating wounds of the eye. It may also result from vascular obstruction such as papilloedema, thrombosis and subarachnoid haemorrhage, from a vascular retinopathy as in nephritis, diabetes mellitus or arteriosclerosis, from toxic states as in malaria, influenza, and dysentery, from local inflammatory conditions in the retina, from senile atherosclerosis, and from diseases of the haemopoietic system. In this respect it is important to bear in mind that about 3 per cent of all myopic retinal detachments are initiated by a gross vitreous haemorrhage which takes some 6–8 weeks to clear sufficiently for accurate fundus examination.

Causes

Possibility of retinal detachment

In most cases the blood is derived from a retinal vessel and occasionally, especially in subarachnoid haemorrhage, remains subhyaloid, that is between the vitreous and retina, producing a characteristic fundus picture. Larger haemorrhages, filling the vitreous with blood, can be diagnosed by the absence of any fundus reflex, by the presence on oblique illumination of a red mass behind the lens, and by numerous red blood cells in the vitreous as seen with the slit-lamp. Any large haemorrhage leaves the vitreous fluid and even when absorption has proceeded sufficiently to allow normal vision, some opacities, usually coloured with blood pigment, remain permanently.

Diagnosis

There is one form of severe vitreous haemorrhage which occurs in apparently healthy young adults, usually males, and which has a distinct tendency to be recurrent (Eales's disease). The cause is obscure but a tuberculous retinal periphlebitis is often the underlying basis Recurrent vitreous haemorrhages, or any large vitreous haemorrhage associated with chronic vascular disease having a toxic basis as in nephritis or diabetes mellitus, have a tendency to

Eales's disease

become organized, the fibrous tissue being derived from mesoblastic elements associated with the central retinal vessels. Hence the proliferative masses of fibrous tissue spreading forwards into the vitreous usually arise from the region of the optic disc (retinitis proliferans).

Retinitis proliferans

Treatment

Rest

The treatment of vitreous haemorrhage is that of the underlying cause, combined with absolute rest in bed in the early stages. Absorption is usually rapid in young and healthy subjects, much slower in the aged, and liable to be complicated by a retinitis proliferans in the presence of syphilis, tuberculosis, nephritis, diabetes mellitus or chronic sepsis. In cases of recurrent haemorrhage attempts may be made to increase the coagulability of the blood by the administration of calcium salts, and the vitamins C, K and P may be of value. Aspiration of the vitreous chamber in such cases has been undertaken but the results are unconvincing and of doubtful value.

8. FIBROUS TISSUE IN THE VITREOUS

Apart from the formations seen in the vitreous in retinitis proliferans, fibrous tissue is found in cases of chronic iridocyclitis from the organization of plastic cyclitic exudates (cyclitic membrane), in cases of plastic endophthalmitis, a subacute form of which is not uncommon in children following an acute specific fever, pneumonia or a post-basic meningitis and is also seen in association with a persistent hyaloid artery. Trauma is also a frequent cause, especially when the choroid, the mesoblastic tissue of which supplies the necessary proliferative elements, has been involved as well as the retina; in war wounds especially it is quite usual to find the track of the missile across the vitreous organized into a fibrous band.

Retrolental fibroplasia

Considerable attention has recently been given to the high incidence of blindness in infants, especially premature infants, which is apparently due to a developmental abnormality—a persistence and hyperplasia of the primary vitreous and to which the term retrolental fibroplasia has been given (Reese, 1949; Klien, 1949; Owens and Owens, 1949).

9. FLUIDITY OF THE VITREOUS

A liquefaction of the vitreous body (synchisis) is the most common feature of its degeneration. It is frequently simply a senile phenomenon, but is also common in myopic eyes, after severe contusion injuries and in most degenerative and inflammatory states of the eye. It is due to a conversion of the colloid gel into a sol and is usually associated with the development of ophthalmoscopically visible particles formed by the colloidal micellae aggregating together into dust-like particles, strands or membranes. The condition cannot be diagnosed ophthalmoscopically in the absence of such opacities but in their presence it is clearly indicated by their free excursion on movements of the eye; with the slit-lamp, however, the change in consistency is always obvious.

Diagnosis

Treatment

There is no treatment for fluidity of the vitreous, its clinical significance lying in the demonstration of degenerative changes occurring in the eye and

the possibility of serious complications if any intra-ocular operation is contemplated.

10. VITREOUS OPACITIES

Opacities in the vitreous may arise exogenously as a result of inflammatory conditions in the uvea or retina and endogenously as a result of degeneration of the vitreous.

(a) *Endogenous*

As a rule the latter are protein coagula derived from the disintegration of the colloid basis of the gel, but occasionally crystalline deposits are found. These may be of two types (1) calcium soaps which occur in relatively healthy but aged eyes, the vitreous being filled with masses of small, discrete, spherical, creamy-white bodies (asteroid bodies), and (2) cholesterol crystals *Asteroid bodies* which are occasionally deposited in a fluid and degenerate vitreous; they tend to be hidden at the bottom of the vitreous chamber with the eye at rest, but form a striking opthalmoscopic picture when stirred up by movements of *Synchisis scintillans* the globe when they appear like a shower of golden rain (synchisis scintillans).

(b) *Exogenous*

Exogenous opacities are of various kinds—protein aggregates and exudative cells associated with inflammatory conditions of the uvea or retina, blood and blood pigment usually derived from a retinal haemorrhage, epithelial cells from the ciliary body, and glial and phagocytic cells from the retina, whilst melanotic pigment granules, both retinal and uveal, are found, sometimes in very large quantities, in old-standing retinal detachments, in glaucoma, after trauma and chronic inflammatory states and with melanotic tumours.

Treatment

The treatment of vitreous opacities is generally unsatisfactory. Inflammatory elements tend to disappear with the passage of time and the subsidence of the primary foci, to the eradication of which treatment must always be directed. The grosser endogenous opacities, crystalline deposits, fibrous tissue strands and membranes persist indefinitely. Iodides and mercury are usually prescribed in the belief that they aid absorption.

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[References to other titles are given under Vitreous—Injuries and Diseases, in the Index Volume.]

VOLVULUS

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1. DEFINITION

349.] Volvulus is a condition in which the gut becomes twisted on itself around a mesenteric axis. This axis is at right angles to the longitudinal axis of the alimentary canal. As a result of such twisting, both the intestinal lumen

and the main vessels at the base of the mesentery concerned become obstructed—a combined state of intestinal obstruction and strangulation is produced.

Volvulus occurs most commonly in the sigmoid colon, the caecal region and the small intestine. Rarely the stomach, gall-bladder, appendix and Meckel's diverticulum undergo this pathological twisting and a congenital type (volvulus neonatorum) will also be described. *Rare types*

Very rarely, instead of a particular coil of the gut twisting on itself, two coils (usually of the small intestine) become intertwined. This is termed a "compound volvulus". *Compound volvulus*

2. AETIOLOGY

Two factors are primarily requisite for the production of a volvulus.

(a) An abnormal elongation of a loop of gut (or an abnormal weighting *or fixity of a loop of normal length*) *such loop being either naturally mobile* or having acquired mobility from some congenital defect. *Primary causes*

(b) A narrowing of the mesenteric base of the loop.

Examples of these factors are megacolon; chronic constipation giving a loaded pelvic colon; adhesions to the convexity of a loop, for example from appendicitis, pelvic inflammation or diverticulitis; incomplete rotations of the gut (as seen particularly with the caecum); and fibrosis of mesenteries from, for example, tuberculous adenitis, and the pericolitis of diverticulitis.

Once these two primary factors exist there are many and various predisposing causes accounting for the actual onset of the twist, such as sudden muscular effort (for example, straining at stool), rapid changes in intraperitoneal relationships (as seen during pregnancy and the puerperium), excessive purgation, prolonged violent exercise and dietetic indiscretions. *Predisposing causes*

3. MORBID ANATOMY

Volvulus is still one of the rarer types of intestinal obstruction occurring in Great Britain. In a recent statistical research Vick (1932) found only 176 cases from 21 major hospitals over a period of 5 years. Cases of volvulus represent something between 2 and 5 per cent of all acute intestinal obstructions in Great Britain. In the United States of America this figure rises to 10 per cent and in the eastern European countries and Russia it is said to account for between one-third and a half of all acute obstructions. The prevalence of diets with a high vegetable content in these latter countries may be responsible for this high figure. *Frequency of occurrence* *Effect of diet*

The basic pathology of all cases of volvulus is that of the "closed loop". The twisting of a normally or abnormally mobile loop obstructs the intestinal lumen at two points and at the same time constricts the vessels entering the mesentery at the hub of the twist. As a result there is very rapid distension of the loop by gas. This distension may, particularly in the pelvic colon, reach fantastic proportions so that the longitudinal striae become difficult to identify and the peritoneal coat splits. It also exaggerates the concomitant vascular changes which lead first to congestion and oedema of the walls of the affected gut. Soon haemorrhages appear and a blood-stained effusion is exuded both to the lumen of the loop and to the peritoneum. *"Closed loop"* *Vascular changes*

Later perforation, either microscopic or gross, occurs and local or general plastic peritonitis develops.

4. CLINICAL PICTURE

Onset The symptoms and signs in a classical case of volvulus are essentially those of any acute intestinal obstruction. In general, men of the later age-groups of 40–60 years are more frequently attacked than women, and a history of constipation is common. The onset is usually sudden, but minor degrees, presumably due to partial twists and natural untwisting, are not infrequently encountered.

Pain Pain is colicky in nature and is felt at and around the umbilicus, at the site of the twist and often in the back on the corresponding side. It is not ~ cessive.

Distension Distension is the outstanding sign and its rapid development and enormo extent are often pathognomonic of the condition. So great is the swelli that the affected loop may occupy most of the peritoneal cavity, the rest c the gut being pushed up and usually to the right under the liver and dia phragm. As a result, respiratory and cardiac embarrassment are commonly found as secondary manifestations. The liver may easily be pushed up as high as the third rib. Hiccup is common and belching of large quantities of gas frequently accompanies it. The distension is so great that visible peristalsis is an uncommon sign, but borborygmi may be heard and felt.

Hiccup

Constipation The patient complains of tenesmus, but except in the very early stages passes neither flatus nor faeces per rectum. Constipation is absolute and, if necessary, may be proved by repeated enemas.

Vomiting Vomiting occurs often at the onset of symptoms but is then conspicuous by its absence until a very late, usually pre-terminal, stage.

General signs Dehydration is evident early; thirst is complained of and the tongue is dry, but otherwise the clinical picture of shock and collapse develops slowly and it will be at least 48 hours from the onset before the effects of strangulation produce the typical anxious facies, subnormal temperature, cold clammy sweat and thready pulse, which in the absence of treatment will usher in the final picture of peritonitis. Not until this latter condition is established will anything but minimal tenderness or rigidity be elicited over the twisted loop.

5. TYPES OF LESION

(1) Sigmoid colon

(a) *Aetiology and pathology*

Frequency Volvulus of the sigmoid colon provides the classical example of this condition. It was at one time thought to be the commonest type of volvulus (75 per cent) but recent figures suggest that its frequency is more in the neighbourhood of 35 per cent. The long omega loop of the pelvic colon, with its normally short mesocolic base, provides the ideal background for a twist. If, as is frequently the case, the loop is loaded from chronic constipation and the base is contracted from pericolitis, the stage is even more perfectly set. The twist is usually anti-clockwise and anything from a half to three complete turns may occur, the upper half of the loop passing downwards and forwards over the lower half.

(*b*) *Clinical picture*

Patients are usually elderly and almost always constipated. Some degree of megacolon is often present. Men outnumber women as patients by 4 to 1. The attack has often been preceded by previous bouts of colicky pain called "indigestion", and constipation, succeeded by diarrhoea and the passage of excessive amounts of flatus. *Onset*

When full volvulus actually occurs the onset is sudden and there is typically a predisposing story of some recent bowel irregularity, a sudden muscular effort or some unexpected change of position.

The clinical picture is as described above—colicky pain with an initial vomit, a rapidly developing enormous distension giving respiratory difficulty and accompanied by belching, tenesmus and absolute constipation. Hiccup and thirst are two of the worst complaints. *Signs and symptoms*

(*c*) *Diagnosis and differential diagnosis*

The diagnosis is made from the history and from the signs—particularly the gross distension.

The absence of pyrexia, of tenderness or rigidity on abdominal palpation and of collapse, serve to distinguish the condition from generalized inflammatory lesions and from perforations. The history and absence of local signs should rule out biliary and renal colic and the enormous distension without vomiting should serve to differentiate volvulus from acute dilatation of the stomach. In the less acute forms a barium enema may be an aid to diagnosis, but the actual weight added thereby to the intestinal contents may predispose to further twisting. Similarly a plain skiagram may assist a doubtful diagnosis, but is seldom necessary. *Local signs*

(*d*) *Treatment*

Treatment calls for immediate laparotomy and this should be delayed as little as possible. Gastric suction and the establishment of an intravenous drip are sound pre-operative measures but little time should otherwise be expended. *Pre-operative treatment*

Attempts to pass a rectal tube or oesophageal bougie through a sigmoidoscope in either the left lateral or genu-pectoral position are most unlikely to be successful, are not without danger of perforating the gut at the base of the volvulus and are very exhausting to the patient. *Rectal tube*

The ideal anaesthetic is spinal; if an inhalation anaesthetic is used (after Pentothal induction) it should be reinforced, in the early stages of the operation at any rate, with intravenous curare. *Anaesthetic*

The abdomen is opened through a long lower left paramedian or central sub-umbilical incision, great care being taken to prevent sudden evisceration of the distended gut when the peritoneum is opened. At this stage a quantity of chocolate-coloured or frankly blood-stained fluid will well out of the wound. It will not usually be possible to do anything definite to the twisted loop, and in particular to see its base, until it is deflated. This can be done by manipulating a previously inserted rectal tube through the hub of the volvulus with the other hand in the abdomen—but the method is often unsuccessful and not without considerable risk of perforation of the friable congested bowel. *Incision* *Deflation of loop*

Puncture

The better way is, after carefully towelling off the area, to make a small puncture hole, preferably through a longitudinal taenia, either with a tenotome or cannula, and surround the puncture with a purse-string suture as soon as the loop has been sufficiently collapsed to take the stitches without tearing.

The problem then facing the surgeon is the old one of deciding as to whether the gut, when untwisted, is viable or not. Untwisting should be done very gently with the deflated loop held carefully between the palms of the hands.

Drainage and fixation

If the gut is viable, it is wise to drain it by a catheter, using the initial puncture hole, through a separate stab incision in the left iliac fossa. This serves not only the purpose of drainage (which in some form is essential in all operations for volvulus) but also of fixation of the loop to the parietal peritoneum—an insurance against recurrence.

Resection

In the unfortunate event of the gut after untwisting not being viable, the affected portion must be excised, the two open ends being brought out and a Paul's tube inserted into each. If all goes well subsequent anastomosis can be carried out.

If only small patches of gangrene are visible on the walls of the affected loop, it may be possible to invaginate these locally. Drainage of the loop in such cases is a vital necessity.

Post-operative measures

Post-operative treatment involves the maintenance of intravenous fluids in the early stages, the early administration of the non-absorbable sulphonamides, Sulfasuxidine or sulphathalidine by mouth, and general measures for the prevention of post-operative respiratory and circulatory complications.

(e) *Prognosis and results*

Causes of death

Volvulus, if untreated, runs a rapidly fatal course in some 2–5 days. Death is due to respiratory complications, to toxaemia, occasionally to bleeding and in the later stages to peritonitis.

Operative mortality

Even when treatment is available, the mortality figures are still high. If resection is not necessary they average about 50 per cent; if resection is called for the figure mounts to 80 per cent.

Recurrence

It should always be remembered that the condition is essentially a recurrent one and until some measure has been taken to anchor the rotating loop, treatment is incomplete. It has been shown above how this can be effected by drainage even at the time of the emergency operation.

(2) Caecum

(a) *Aetiology and pathology*

Abnormalities of mid-gut loop

Volvulus of the caecum implies some congenital fault in rotation or fixation of the embryological mid-gut loop. Normally the caecum is relatively fixed in the right iliac fossa. If it is free enough to undergo rotation, there must of necessity be some persistence of an ileo-caeco-colic mesentery. This may be associated with either non-rotation or reversed rotation of the mid-gut loop and the caecum may lie high up in the right, usually, or left subdiaphragmatic region. It is said that some 15–25 per cent of normal individuals possess such a freely swinging right colon. Hence it is probable that volvulus of the caecum is more prevalent than was previously recognized—particularly in

its milder degrees. Vick (1932) estimated that only 13 per cent of all cases of volvulus were caecal. In contra-distinction to this, Gardiner (1947) reports 15 personal cases of his own in the past 5 years. It is worthy of note that this abnormal mesentery may be so long and loose that a volvulus of the caecum can be found in the lesser sac (Ogilvie, 1949). *Frequency*

Predisposing causes are as listed above, with the addition of constriction of the mesenteric base secondary to adenitis from various causes. The association of manual labour, sudden exercise or muscular strain, especially when combined with purgation, probably accounts for the fact that the incidence in males is three times that in females. *Predisposing causes*

(*b*) *Clinical picture*

There is a tendency for caecal volvulus to occur in a younger age-group, some 50 per cent being between the ages of 20 and 40 years, but a number of cases over 60 years of age are on record. The onset is again typically sudden and the course may be hyperacute. Death has been reported within 5 hours of onset. Nevertheless, the more insidious onset of partial or recurrent volvulus is more common here than on the left-hand side. *Age*

Generally speaking, the whole picture is less acute and gangrene of the affected loop is quite rare. It is uncommon for the twist to be through more than 80 degrees and the direction may be either clockwise or anticlockwise. *Twist*

The pain varies between the right iliac fossa, the umbilicus and the epigastrium according to the site of the caecum. The initial vomit is as before, but the distension, although considerable, is markedly less than that of the pelvic colon. Constipation is absolute but general signs are in the early stages conspicuous by their absence. *Clinical signs*

(*c*) *Diagnosis*

Diagnosis is usually made on history and clinical signs alone, but x-ray examination can be of some value particularly in differentiating the distension from that of acute dilatation of the stomach. In non-descent of the caecum and volvulus the maximal distension can easily be mistaken for that of the stomach. *X-ray examination*

Obviously right iliac fossa signs need differentiating from those of subacute appendicitis. This is particularly the case in the partial recurrent type of volvulus attack. The absence of inflammatory signs and symptoms should serve to separate these two pictures.

(*d*) *Treatment*

Routine pre-operative transfusion, gastric suction and lavage should be instituted as required, but laparotomy at the earliest opportunity is urgently indicated. *Pre-operative measures*

Approach should be made through a long right paramedian incision half above and half below the umbilicus. *Incision*

The volvulus can often be delivered without deflation, though this should be done by puncture as described above (*see* Sigmoid Colon, p. 582) if there is any difficulty in dealing with the obstructed loop. In this connexion it should be remembered that the caecum when distended and congested is particularly

friable and calls for the most gentle handling. Once the volvulus has been untwisted, further treatment depends on the viability or otherwise of the affected gut.

Fixation

(a) If the gut is viable (which is usually the case) the loop may be either left *in situ*, fixed by careful suture to the fascia over the iliacus muscle, or drained by a catheter caecostomy and so fixed to the anterior parietal peritoneum. The last method is probably the wisest.

Excision

(b) If not viable, and if the gangrenous areas are too large to be treated by local purse-string invagination, the loop must be either exteriorized and later removed, drainage being affected by two Paul's tubes until such later time as secondary anastomosis can be carried out; or a formal excision of the right colon may be performed, with ileo-transverse colostomy. If the patient's general condition justifies the latter method, it is the preferable one. The long free mesentery in these cases makes the excision a considerably easier proposition than it is when the anatomy is normal.

(e) *Prognosis and results*

Mortality

The condition, if untreated, is invariably fatal and on the average more rapidly so than in volvulus of the sigmoid colon. The operative mortality varies between 45 per cent if the loop is viable and 65 per cent if resection is necessary.

The marked tendency to recurrence must be borne in mind and when excision is not called for some method of fixation should always be adopted.

(3) Small intestine

(a) *Aetiology and pathology*

Volvulus associated with caecum

Volvulus of intestine alone

Volvulus of the small intestine is usually found in association with volvulus of the caecum and is similarly due to some degree of congenital incomplete rotation of the mid-gut loop with defective fixation of the mesentery. This combined group accounts for more than half the total cases of volvulus (Vick, 52 per cent). Its effects are therefore more particularly observed in the distal portion of the small intestine, but approximation of the fixed points of attachment of the mesentery may reduce this to a relatively narrow pedicle and so make possible rotation of the whole small intestine or individual parts of it. The narrowness of this pedicle predisposes to early strangulation. The condition has aptly been described as "knotting" and in this connexion the possibility of two separate coils of small intestine becoming intertwined ("compound volvulus") must be borne in mind. The turns in small intestinal volvulus are usually clockwise and may be as many as four or five. It is the tightness of the twists rather than their number which determines the subsequent clinical picture.

Knotting

Compound volvulus

Predisposing conditions

There are a number of conditions which predispose to the formation of intestinal volvulus, amongst which may be listed the following: the fibrosis secondary to mesenteric adenitis, especially tuberculous; the occurrence of bands and adhesions to an individual coil or coils, either post-operative or otherwise; the presence of tumours of the small intestine or of cysts of the mesentery; the attachment of a Meckel's diverticulum; and the impaction of a gall-stone. The possibility of gut inside a hernial sac becoming twisted owing to the narrowness of the neck is also occasionally realized.

(b) *Clinical picture*

Volvulus of the small intestine occurs in much younger age-groups than other types. It is frequently found in children and practically always before middle age. The clinical picture is that of small intestinal obstruction which is much more acute than in the large gut volvulus. Shock is marked and is soon exaggerated by the dehydration consequent on the copious vomiting which is a predominant feature. Distension is a much less obvious sign and, owing to the early onset of gangrene, peritonitis with its classical clinical picture supervenes rapidly. *Age* *Shock*

(c) *Diagnosis*

The diagnosis may be very difficult before laparotomy, as many conditions give a very similar clinical picture. Mesenteric thrombosis, strangulation of an internal hernia, acute pancreatitis and the intestinal impaction of a gall-stone are the most likely conditions to be mistaken for a volvulus. Radiological examination, except that it may discover an opaque gall-stone, is of little value.

(d) *Treatment*

Laparotomy is called for urgently as soon as routine pre-operative gastric suction and intravenous infusion have been instituted. If operation is performed early enough, simple unwinding may be sufficient, though the predisposing cause of the volvulus must be sought for and suitably dealt with. Usually, as gangrene of the bowel occurs rapidly, an excision of the twisted loop and end-to-end anastomosis is called for. The procedure unfortunately still carries a mortality rate of approximately 65 per cent. *Pre-operative* *Operative mortality*

6. RARE TYPES OF VOLVULUS

(1) Volvulus neonatorum

(a) *Aetiology and pathology*

This condition is, like caecal volvulus, due to faulty rotation of the mid-gut loop, the maximal effect in these cases being felt at the duodenal end of the loop. Pre-natal cases have been described but the condition usually becomes evident after the first few days of life.

The onset of symptoms may be delayed for a few weeks. The lack of fixation of the loop, the caecum usually being in the upper right hypochondrium leaves a freely swinging gut pivoting on the superior mesenteric artery. Volvulus is presumably initiated by the peristalsis, at first often irregular, subsequent to the taking of food. There would appear to be no hereditary element in the condition, but it is well known to be frequently associated with other congenital abnormalities, and hydramnios in the mother has been reported on occasions (Forshall, 1947). *Onset*

The volvulus, which is a clockwise turn, is always through a complete circle of 360 degrees and often goes on to as many as 6 turns and produces an extrinsic obstruction of the duodenum. Usually only the proximal limb is obstructed and interference with blood supply is the exception rather than the rule. *Obstruction of duodenum*

(b) Clinical picture

Vomiting

Apart from the various atresias of the alimentary canal, volvulus neonatorum is probably the commonest cause of intestinal obstruction in the newborn child (Dott, 1927). Male and female infants are equally affected. The predominant sign is vomiting starting typically towards the end of the first week of life. This vomit contains much bile. Dehydration (and subsequent ketosis) develops rapidly and the wizened and apathetic appearance of the infant is pathognomonic of a high intestinal obstruction. Distension is not a marked feature, but visible peristalsis in the stomach can sometimes be seen and occasionally a little blood-stained mucus is passed per rectum.

(c) Diagnosis

X-ray examination

The chief differential diagnosis is obviously from hypertrophic pyloric stenosis, the clinical picture of both being very similar. In volvulus, however the presence of bile in the vomit is an important point and the absence of the pyloric "tumour" may assist diagnosis. X-ray examination is of great value, the gaseous distension of the proximal parts of the duodenum seen on a plain skiagram ruling out pyloric stenosis, which latter condition can be further excluded by the swallowing of a little barium emulsion.

(d) Treatment

Anaesthetic

Test of cure

Operation is the only treatment. As considerably more inspection of abdominal contents and a wider field of exposure for actual technical manipulation are required than for pyloric stenosis, a general anaesthetic is indicated. Approach is made through a supra-umbilical midline incision and the volvulus sought for. This may be much more difficult than it sounds, as there is often minimal distension—one loop only being obstructed—and frequently no discoloration, strangulation being rare and late. The twist, when found, is gently undone and subsequent patency of the gut is tested by milking gas through the affected portion. If all is well, the floating caecum should then be fixed by stitching to the parietal peritoneum in the right hypochondrium and the abdomen closed. If, after untwisting, air will not pass through the affected duodenum, it is likely that a concomitant atresia of the third part, due to an abnormal peritoneal reflection forming a band, is also present and this will have to be divided.

(e) Prognosis and results

Good results

In the absence of operation the infant will invariably die about the twelfth or fourteenth day. Results of operation are surprisingly good, owing to the facts that diagnosis is usually made early, that obstruction is limited and that strangulation is rare. Ladd (1937) quotes an operative mortality of only 14 per cent.

(2) Volvulus of stomach

(a) Aetiology and pathology

Pyloric obstruction

Volvulus of the stomach occurs only in a ptosed and hypermobile organ. The twist may be either partial or complete and occur on either a vertical or horizontal axis. Usually the greater curvature turns upwards and inwards. The resulting pyloric obstruction is complete but there is little effect on

circulation. The condition is frequently associated with the presence of a growth, surrounding adhesions or an hour-glass deformity and has been most commonly reported in conjunction with diaphragmatic hernia.

(b) Clinical picture

Patients are typically middle-aged and have a long-standing dyspeptic history. The attack of volvulus is often precipitated by overfilling the stomach. After a preliminary copious vomit the outstanding feature is continued forcible retching. Some epigastric pain and tenderness may be complained of and shock is always present. *Retching*

(c) Treatment

Volvulus of the stomach is treated by operation. The stomach frequently requires emptying of gas before it can be untwisted. Some form of gastropexy is called for to prevent recurrence. *Gastropexy*

(3) Transverse colon

Volvulus of the transverse colon is extremely rare, owing chiefly to the relatively long distance between the points of fixation of the mesocolon at the hepatic and splenic flexures. In cases reported, there has usually been some accompanying lesion such as a growth, megacolon (River and Gubler, 1943), limitation of movement by adhesions or constriction of the mesocolic base by extension of nearby inflammatory processes.

(4) Gall-bladder

The clinical picture is comparable to that of sigmoid volvulus and treatment is on similar lines. Torsion of the gall-bladder postulates the existence of a complete peritoneal covering and the existence of a mesentery. Pre-operative diagnosis is virtually impossible. Treatment is by cholecystectomy.

(5) Appendix and Meckel's diverticulum

Volvulus of these organs as such is simply a pathological curiosity. By their length or attachments they may initiate or take part in an intestinal volvulus. Diagnosis of such a condition could only be made at operation and treatment is removal of the organ complete.

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YAWS

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1. DEFINITION

350.] Yaws is a contagious, non-venereal disease of coloured peoples, the course of which closely resembles that of syphilis; it is of wide incidence in tropical countries.

2. AETIOLOGY

Distribution

Yaws occurs in endemic proportions in East, West and tropical Africa. It [illegible] er numbers [illegible] Philippines [illegible] of the West Indies and in central America.

Infection

Infection is due to the entry of the *Treponema pertenue* through a breach

of the skin surface and is most common in childhood. The characteristic lesion, said to resemble the raspberry, appears after a period of several weeks, and is crusted and yellow. The presence of the *T. pertenue* may be demonstrated in the red, pulpy granulation tissue beneath.

Contributory factors

Climate

Over-crowding

The disease is most common where rainfall is heavy and vegetation profuse, and exacerbation during wet seasons is a common observation. Crowded dwelling places and restricted sleeping quarters are contributory factors.

Trauma

Naked children are particularly exposed to trauma of the skin, especially of the feet and legs. The infection is almost certainly directly acquired from one already the subject of the disease.

Vectors

The skin lesions attract numerous flies, and these have been proved experimentally to be capable of conveying the infection. Yaws is very rarely acquired by white people; cases of accidental infection have been reported, followed after an interval by the appearance of the typical mother yaw, in which the presence of the spirochaete has been demonstrated. Treatment has been equally efficacious.

3. PATHOLOGY

Causative organism

The responsible organism is the *T. pertenue*, which is morphologically indistinguishable from the *T. pallidum* and can similarly be stained and demonstrated by dark-ground illumination.

Mother yaw

Secondary yaws

The primary lesion or mother yaw appears at the site of inoculation after an incubation of 4–6 weeks, and may be superimposed upon an existing ulcer. The incidence is especially high amongst young children, but susceptibility is never lost. It begins as a nodule in the skin, becomes crusted, and exudes a sticky discharge; beneath is the soft red granuloma. Treponemas are present in large numbers. The secondary phase occurs after a variable period up to about 4 months, and is characterized by widespread eruptions, similar for the most part to the mother yaw. Successive crops may prolong this stage for a year or more, which may be accompanied by considerable constitutional disturbance.

Tertiary yaws

Further manifestations and complications which extend beyond the stage of secondary eruption are regarded as tertiary conditions, but the distinction is by no means sharp.

Blood reaction

The Wassermann and Kahn tests become positive within a few weeks. On the whole the Kahn test is to be preferred. The reaction remains positive for the most part in spite of treatment. Periods of quiescence and reactivation occur throughout life.

4. CLINICAL PICTURE OF SECONDARY AND TERTIARY YAWS

(1) Skin

(a) Ulceration

Site

Ulceration may succeed the secondary eruption, or be delayed for many years. The process is most common in the legs, and resembles the syphilitic

ulcer. The edge is usually well defined, with little surrounding tissue reaction. The superficial tissues only may be involved, but on the other hand the condition may be deeply invasive and destructive.

(*b*) *Solitary sessile plaques*

These remarkable lesions usually occur upon the neck, shoulders or scrotum and attain a considerable size. They begin as raised circular areas somewhat resembling keloids, and become pale and shiny. Desquamation occurs as a preliminary to ulceration.

(2) Feet and hands

The following lesions were found in West and East African troops during World War II.

(i) *Fissuring.*—Deep transverse fissures behind the metatarsal heads and plantar arch; painful bleeding cracks on the plantar surface and proximal creases of the toes; and deep longitudinal cracks 1–1½ inches long between the first and second metatarsal heads, but rarely involving the web.

(ii) *Ulceration.*—Deep circular pits with keratinized margins ¼–½ inch in diameter, often opening into a flask-shaped cavity, resembling a perforating ulcer of the sole.

Pepper-pot appearance

(iii) *Pitting.*—Multiple small pits, giving a "pepper-pot" appearance to the sole, usually associated with fine fissures.

(iv) *Erosion.*—Ragged irregular ulceration mainly of the heel, instep and behind the first metatarsal head.

Artefacts

A good imitation of the "pepper-pot" appearance can be produced by cutting the sole of the foot with a piece of glass tubing, and this device was employed by those who wished to "dodge the column". Such lesions are, however, uniform in size, circular, and do not open into the subdermal space.

Hands

Similar changes are observed on the palms of the hands.

(3) Bones

Frequency of infection

In endemic areas yaws is the commonest cause of disease in bones and joints, and occurs in bones most subject to injury. The frequency with which particular bones are affected varies with different observers, but lesions of the tibia are by far the most frequent. In a personal series of 247 cases of tertiary yaws amongst troops from Nigeria, Gold Coast, Sierra Leone and Gambia, bone and periosteum were involved in 38, in the following proportions:

Tibia	22	Clavicle	2
Phalanges	5	Fibula	1
Ulna	3	Skull	1
Femur	3	Rib	1

(*a*) *Periosteal nodes*

Lesions are commonly encountered on the anterior aspect of the tibia and long bones (Fig. 258). In the acute stage there is local heat and tenderness, and the skin may be glazed. Response to treatment may be dramatic.

(*b*) *Diffuse osteoperiostitis* (Fig. 259)

The periosteum is hyperaemic and thickened, giving the impression of a general enlargement of the bone. The part is hot, and tender locally to remote percussion. The condition is often bilateral, but only one limb may cause

complaint. There is irregular pyrexia, considerable constitutional disturbance, *Pyrexia* and often loss of weight and mental apathy. Backache and myalgic pains *Backache* are common.



FIG 258.—Localized osteoperiostitis, with bowing of femoral shaft. (*By courtesy of Col. A. M. Simson, formerly A.D. M.S Nigeria.*)

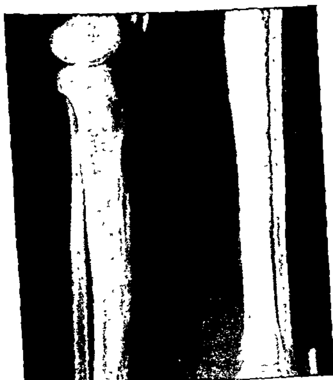


FIG 259.–Secondary yaws Diffuse osteoperiostitis, and cortical erosion. (*By courtesy of Col. A. M Simson, formerly A.D M.S. Nigeria*)

(c) *Chronic osteitis*

The initial hyperaemia and softening of the long bones often produces an increase in the anterior convexity of the tibiae, and the typical sabre deformity (Fig. 260). The whole shaft may be increased in diameter, with increased cortex and reduction of medullary space. Tenderness is diffuse, and exacerbation induced by slight trauma. Pain is increased by exposure and fatigue,

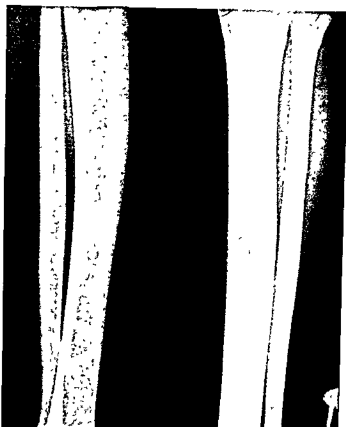


FIG. 260—Bowing of tibia, with cortical sclerosis. (*By courtesy of Col. A. M. Simson, formerly A.D.M.S. Nigeria.*)

and is commonly worse at night. Subsequent ulceration of soft tissue, bone destruction and scarring may produce gross deformities. *Spontaneous fractures* Spontaneous fractures may occur and repair in such cases is slow.

(d) *Polydactylitis*

This condition is relatively common. The history is usually short, and the complaint is of pain, and loss of power in hands and fingers. *Radiological features* Radiologically the outstanding features are the multiplicity of irregular cystic spaces throughout the phalanges and metacarpus. Cysts often appear first in the heads of the proximal and intermediate phalanges. Rarefaction is most marked in the interphalangeal joints. Sclerosis may be observed in the central portions of the phalangeal and metacarpal shafts, and may become bulbous in form. The axes of both metacarpal and interphalangeal joints show varying degrees of distortion. *Prognosis* In general, the more acute the condition, the more rapid is the response to treatment, and the hand may be restored practically to normal within a few months.

(e) *Epiphysitis*

The epiphyses are subject to acute infection. The onset is sudden, and the



FIG. 261.—Tertiary yaws, bone sclerosis and expansion of shaft (*By courtesy of Col. A. M. Simson, formerly A.D.M.S. Nigeria*)



FIG. 262.—Tertiary yaws, sclerosis and expansion of shaft (*By courtesy of Col. A. M. Simson, formerly A.D.M.S. Nigeria*)

pain, fever and toxaemia simulate *acute osteomyelitis*. The condition is characterized by extreme hyperaemia of the periosteum and adjacent bone.

(f) Differential diagnosis of bone lesions

A wide variety of appearances is evident in skiagrams, and it is often difficult or impossible to distinguish the disease from syphilis by radiology alone. Changes in the texture of cortical bone, and the appearance of ill-defined areas of rarefaction or translucence may be seen within a few weeks

Periostitis

Periostitis alone is rare, which may help to distinguish yaws from syphilis Irregular cystic spaces precede cortical erosion and loss of linear outline. In the more chronic state the cortex becomes sclerosed, with increase in the

Sequestration

diameter of the shaft (Figs. 261 and 262). Sequestration, as an intrinsic complication, does not appear to arise, although this must be distinguished from the ulcerative process which invades the bone from without. Bowing occurs in bones subject to weight bearing. Circumscribed cysts in long bones

Diffuse osteitis

are not uncommon. In diffuse osteitis new bone formation may resemble osteogenic sarcoma.

(4) Joints

Synovitis, fasciitis and myalgia are common manifestations of secondary and tertiary yaws. *The complaint is commonly of a stiff and painful back* of short history and accompanied by fever. Pain is not usually ascribed to the vertebral column, but is referred to the glutei and thighs, neck and shoulders The patient may present a picture of apathetic misery. The response to a single injection of N.A.B. may be little short of miraculous.

Juxta-articular nodes

These nodes arise in relation to the larger joints, and are generally multiple,

Common sites

symmetrically placed, and commonest about the knees and elbows. They vary in size from a small hard nodule to a solid tumour the size of a tennis ball and sufficient to be the cause of mechanical hindrance. They rarely appear before middle life, and are painless for the most part. If excised they tend to recur. The incidence is commonest in untreated yaws. Juxta-articular nodes are often incorrectly described as being subcutaneous.

Case report

A middle-aged African presented himself with a solid ovoid tumour 2½ × 1½ inches at the medial aspect of the knee joint. On exploration the tumour was exposed deep to the capsule, but was extrasynovial and attached to neither structure It was firmly fixed by fibrous tissue to the medial aspect of the patella Operation was followed by a course of N.A.B., and there was no recurrence

(5) Ganglia

glia are common at the wrists and to a lesser degree on the dorsum of et, and may occur in connexion with a tenosynovitis. *They may attain* siderable size, and are lax, thin-walled, and lack the tensity and fixity : ordinary ganglion. Like the compound ganglia, they contain loose, ous bodies which grate under the touch. X-ray examination *of the carpus* how a subjacent rarefaction. Response to treatment is rapid, and inter- n is rarely justified. Somewhat similar tumours are encountered apart

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A wide variety of appearances is evident in skiagrams, and it is often difficult or impossible to distinguish the disease from syphilis by radiology alone. Changes in the texture of cortical bone, and the appearance of ill-defined areas of rarefaction or translucence may be seen within a few weeks.

Periostitis

Periostitis alone is rare, which may help to distinguish yaws from syphilis. Irregular cystic spaces precede cortical erosion and loss of linear outline. In the more chronic state the cortex becomes sclerosed, with increase in the diameter of the shaft (Figs. 261 and 262).

Sequestration

Sequestration, as an intrinsic complication, does not appear to arise, although this must be distinguished from the ulcerative process which invades the bone from without. Bowing occurs in bones subject to weight bearing. Circumscribed cysts in long bones are not uncommon.

Diffuse osteitis

In diffuse osteitis new bone formation may resemble osteogenic sarcoma.

(4) Joints

Synovitis, fasciitis and myalgia are common manifestations of secondary and tertiary yaws. The complaint is commonly of a stiff and painful back of short history and accompanied by fever. Pain is not usually ascribed to the vertebral column, but is referred to the glutei and thighs, neck and shoulders. The patient may present a picture of apathetic misery. The response to a single injection of N.A.B. may be little short of miraculous.

Juxta-articular nodes

Common sites

These nodes arise in relation to the larger joints, and are generally multiple, symmetrically placed, and commonest about the knees and elbows. They vary in size from a small hard nodule to a solid tumour the size of a tennis ball and sufficient to be the cause of mechanical hindrance. They rarely appear before middle life, and are painless for the most part. If excised they tend to recur. The incidence is commonest in untreated yaws. Juxta-articular nodes are often incorrectly described as being subcutaneous.

Case report

A middle-aged African presented himself with a solid ovoid tumour $2\frac{1}{2} \times 1\frac{1}{2}$ inches at the medial aspect of the knee joint. On exploration the tumour was exposed deep to the capsule, but was extrasynovial and attached to neither structure. It was firmly fixed by fibrous tissue to the medial aspect of the patella. Operation was followed by a course of N.A.B., and there was no recurrence.

(5) Ganglia

Ganglia are common at the wrists and to a lesser degree on the dorsum of the feet, and may occur in connexion with a tenosynovitis. They may attain a considerable size, and are lax, thin-walled, and lack the tensity and fixity of the ordinary ganglion. Like the compound ganglia, they contain loose, fibrinous bodies which grate under the touch. X-ray examination of the carpus may show a subjacent rarefaction. Response to treatment is rapid, and intervention is rarely justified. Somewhat similar tumours are encountered apart

from synovial sheaths. Deep-seated, well-defined elastic swellings have been located in the calf and popliteal fossa. On excision these have shown a well-defined *fibrous structure containing tissue fluid, and are easily separated* from their surroundings.

(6) Gangosa

Gangosa is a tertiary manifestation which resembles syphilis in its most destructive form. This mutilating condition attacks and invades the nose and upper pharynx, destroying skin, mucous membrane, cartilage and bone (Fig. 263). The orbits and their content may be invaded, but the upper lip appears to be resistant until late in the disease. The antra and palate may be involved early, but the tongue usually escapes. *Site of invasion*

Case report

A West African patient, aged 20 years, exhibited considerable destruction of the nasal cartilage, mucous membrane and bone, with invasion of the antra and palate. There was profuse muco-purulent discharge. *In addition the trachea was* compressed laterally by a solid tumour the size of a billiard ball. Respiration was considerably embarrassed. Rapid relief was obtained by treatment, and the progress of the disease was arrested.



FIG 263.—Mutilation resulting from gangosa (*By courtesy of Mr. Maurice Ellis, formerly of the Colonial Medical Service*)

(7) Goundou

This is a secondary condition characterized by the appearance of sym-



(a)



(b)

FIG. 264.—(*a*) and (*b*) Showing appearance of goundou (*By courtesy of Mr. Maurice Ellis, formerly of the Colonial Medical Service*)

metrical bony bosses on either side of the nose (Fig. 264). These arise from the superior maxillae as the result of a low grade inflammatory reaction and subsequent periostitis. Suppuration does not occur as in gangosa.

5. DIAGNOSIS

Differential diagnosis

The main difficulty in diagnosis lies in the distinction between yaws and syphilis. The blood serum reactions are similar. Yaws is not venereal and not congenital. There is no characteristic endarteritis as in syphilis. Visceral lesions and disorders of the central nervous system are not associated with yaws. Bone changes in yaws are more rapid, more painful, and associated with greater constitutional disturbance. The ready response to arsenicals is in itself a diagnostic aid. Radiology helps to differentiate from osteomyelitis and osteosarcoma.

Juxta-articular nodes may be confused with onchocercal cysts which are multiple, and occur in similar situations. The distinction is easily made on excision and macroscopic section.

Causes of ulceration

Ulceration, particularly of the lower limb, may be due to syphilis, tropical ulcer, guinea-worm, dietary deficiency and trauma; other yaws lesions may be present. As a rule the yaws ulcer responds well to treatment. The superimposition of yaws infection upon an existing ulcer should be borne in mind.

6. TREATMENT

(1) General

General measures are undertaken to make up the common deficiencies in diet, the eradication of intestinal parasites, and the provision of adequate rest.

(2) Local

The following is an outline of treatment of foot yaws carried out in a military hospital.

Aims of treatment

Hot soaks were given in soapy water twice daily, and unguentum acid salicyl was rubbed well into the sole. The hard, keratinized overhanging layers of skin were pared, the aims being to flatten fissures, pits and cracks, and to remove debris and foreign matter without causing bleeding. Silver nitrate, 5 per cent, in spirit was also used as a paint.

The majority of patients received weekly injections of N.A.B., 0·45 gramme, followed by 0·6 gramme. Regular treatment of the feet with unsaturated vegetable or animal oils, especially during periods of stress, and the avoidance of exposure to wet and cold, materially reduced disability.

(3) *Specific*

Arsenicals

Duration of treatment

[illegible] of choice. [illegible] pon the primary yaw, or secondary lesions of skin and bone. The length to which treatment should be extended, and the criterion of cure, are uncertain. Relapse after a period of latency is common, and the unaltered Kahn reaction may indicate under-treatment.

An average course may be regarded as a total of 5 grammes, given over a period of 6–8 weeks. Bismuth may be employed usefully as an adjunct, and in some countries is used as the primary medicament. *Bismuth*

It is impossible at the present time to weigh the respective merits of arsenicals and penicillin, used separately or in conjunction. It is certain, however, that the *T. pertenue* is extremely sensitive to the action of penicillin; that healing time and clinical cure are accelerated thereby, and that in every respect results are at least equal to those obtained with arsenicals. Hill, Findlay and Macpherson (1946) recommend the injection of 100,000 units in oil given once or twice daily, to a total dosage of 1,000,000–1,500,000 units. A single injection may result in the disappearance of the organism and render the individual non-infective to the community. Early diagnosis and prompt treatment are therefore important measures in reducing the incidence of the disease. *Penicillin*

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